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Prior Knowledge Assessment Guide

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14. ABSTRACT *(Maximum 200 words)*:
The goal of Army instructors is to deliver the best possible instructional experience so students can increase their knowledge and transfer it to their duty positions. A major means of accomplishing this goal is to tailor training to the individual student, a concept espoused in the Army Learning Model. In order to tailor training, one must first identify the critical differences that distinguish individuals who are likely to have problems with course content vs. those who will not. One objective of ARI's tailored training research is to identify measures which predict student performance in a variety of courses with different student populations. In agreement with the research literature, relevant prior knowledge has been consistently found to be the best predictor of later performance. It was also determined that experienced instructors had a good understanding of what prior knowledge was relevant for their courses. The purpose of the guide documented in this report is to provide instructors the tools necessary for developing appropriate assessments of prior knowledge, to determine whether these assessments are a good predictor of course performance, and to show them how to apply prior knowledge and course performance data to identify the students who could benefit from tailored training.

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PRIOR KNOWLEDGE ASSESSMENT GUIDE

EXECUTIVE SUMMARY

Research Requirement:

A central tenet within the U.S. Army Training and Doctrine Command's (TRADOC) Army Learning Concept 2015 (ALC) and Army Learning Model (ALM) is the need to transition to learner-centric methods and processes that develop critical competencies through rigorous, tailored, outcome-oriented learning experiences. Despite this goal, the ALC and ALM do not provide guidance on how to effectively identify students who could benefit from tailored training experiences. One of the objectives of the Army Research Institute's (ARI's) tailored training program is to determine the types of measures that predict performance in Army courses. These measures could then be used to identify students likely to have problems in the course or those who need to be challenged, so instructors could address the needs of these individuals through tailored training. The result of ARI's research efforts showed that relevant prior knowledge was the most consistent predictor, a result consistent with the academic literature. Since neither the ALC nor the ALM provided guidance to instructors on how to identify students who would benefit from tailored training, the prior knowledge assessment guide presented in this report was developed to fill that training gap. It was based heavily on the lessons learned from ARI's tailored training research, and was designed to assist training personnel in identifying levels of prior knowledge in students prior to instruction.

Procedure:

A guide was developed that provides step-by-step instructions for developing a Prior Knowledge Assessment. The guide provides background information on prior knowledge assessments, procedures for developing a prior knowledge assessment, developing questions, procedures for validating prior knowledge assessments, information on using and revising assessments, and practical exercises to assist developers in understanding major concepts and procedures in the guide. The guide was distributed to three selected training institutions to obtain feedback on the content, organization, clarity, ease-of-use, readability, and understandability of the material presented in the guide.

Findings:

The guide was demonstrated to contain the appropriate information developers need to create Prior Knowledge Assessments. Feedback indicated that while the reviewers thought that the guide was well written and informative for creating a Prior Knowledge Assessment, it did include some concepts that more junior level instructors found challenging to understand and employ. On the other hand, positive feedback was provided by senior level personnel, including senior trainers, training managers, course developers and other senior training personnel, regarding the guide's utility. Thus, it appears that the prior knowledge assessment development activities framed within the guide are best accomplished by more senior, experienced training personnel.

Utilization and Dissemination of Findings:

The guide can be used in training institutions throughout TRADOC by those who want to develop Prior Knowledge Assessments to predict student performance, which in turn can be used to identify students who could benefit from tailored training. It is designed for training developers, course managers, experienced instructors, and other senior level training personnel. In addition, it is most applicable for use in technical or extended training courses, portions of courses, or specific blocks of training that require formal standards of proficiency as students in these training settings generally benefit most from tailored training. Assessing prior knowledge in these training situations makes it easier for the instructor to effectively tailor training to meet individual student needs. Predicting student performance in other Army training situations where the intent is to "familiarize" students with information might be less beneficial. Final copies of the guide and this report will be provided to each of the training institutions that provided inputs and feedback during its development. Additionally, copies will be provided to other TRADOC agencies upon request.

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Prior Knowledge Assessment Guide

Background

The ultimate goal of Army instructors is to deliver the best possible instructional experience to their students in order to increase learning and to facilitate the maximum transfer of knowledge. To accomplish that goal, an instructor needs to consider individual differences in the background and knowledge of students in a class. The diversity of backgrounds and knowledge of students within Army classrooms can be substantial, which in turn warrants attention to individual differences that impact the learning process.

Tutoring is often cited as the best means of maximizing learning as it addresses individual differences. Bloom's (1984) classic article on tutoring is often cited as support for this. However, one-on-one tutoring is not logistically feasible in Army classrooms. Yet some form of tailoring instruction to students, by distinguishing, at a minimum, between those who will struggle with the material and those who will easily excel, can be achieved. In FY09 the Army Research Institute (ARI) Research Unit at Fort Benning, GA started a multi-year research program on tailored training with the ultimate objective of developing training approaches to address critical individual differences in Soldiers' backgrounds and skills to make training more effective, meaningful and efficient.

Initial research in this tailored training program was on determining what assessment instruments or measures were effective in predicting differences in Soldier performance in a variety of courses; assessment instruments that could be used by an instructor as early indicators of Soldiers who would need assistance and/or Soldiers who would excel and should be challenged. While this research was in progress, the Army's Training and Doctrine Command (TRADOC) published the Army Learning Concept (TRADOC, 2011), which outlined the Army Learning Model (ALM). One of the principles in the ALM is that Army institutions must account for students' prior knowledge and experiences by assessing competencies and appropriately tailoring learning to students. No further information was cited regarding how this objective could be accomplished or how to assess prior knowledge and experiences.

The Prior Knowledge Assessment Guide presented in this report is based on the research efforts and lessons learned in developing predictors of Soldier performance emerging from ARI's tailored training research program. This research has consistently shown that the best predictor is an assessment of relevant prior knowledge; knowledge which is specific to key concepts and practices within the course content. The guide also addresses the TRADOC's ALM objectives by presenting procedures by which senior instructors, training managers, and course developers can generate measures that predict or estimate Soldier performance and can assess the adequacy of the measures they develop. However, the guide does not inform the user how to tailor training, only how to identify students who may benefit from some form of tailored training. It should also be noted that while much of the supporting literature uses the term "test," for the purposes of the guide and this report, the term "assessment" was chosen to reduce potential confusion with graded events and other training metrics.

Predictors of Achievement and Performance

The body of research on identifying predictive measures of human performance and/or achievement is large. Often, when people think of predictive measures they first think of using such measures for personnel selection for jobs or for college admission. The assumption is that these measures can identify individuals who will perform well on the job or at a specific college. The military itself has a long history of developing measures of mental ability or cognitive skills for personnel selection; beginning with World War I (Zeidner & Drucker, 1988). Efforts continue to the present to develop measures that will provide better selection tools for military branches and occupational specialties (e.g., Allen &Young, 2012; Heffner, Campbell, & Drasgow, 2011; Howse & Damos (2011); Knapp & Tremble, 2007; Zook, 1996). A variety of variables can be used for selection purposes. Common variables include mental or cognitive ability, prior work experience, prior knowledge, past performance, acquired skills, physical ability and personality traits (Dakin & Armstrong, 1989, U.S Department of Labor, 2006).

The purpose of predictive measures for tailoring training is slightly different, in that you need some means of distinguishing among students who need different types of learning experiences or conditions in order to succeed in a formal training setting. One of the issues associated with such predictors is that the criterion, achievement in a classroom, is not stable; it is dynamic, and what an individual learns changes over time while instruction occurs. Therefore, predicting achievement with a high degree of accuracy is very difficult. Dyer (2004) in a discussion of why predictors are difficult to find referred to Regain and Schneider's (1990) examination of Air Traffic Controller selection. Regain and Schneider reported that an extensive battery of tests to select air traffic controllers after President Reagan decided to replace striking controllers did not work. Only 2 percent of 70,000 applicants were selected and about half of these failed the training. The authors attributed this to two factors. One was poor mapping between the predictor and criterion measures in that the predictor measures pertained to relatively trivial components unrelated to the criterion test. The second factor was ignoring "skill plasticity". Research on skill learning clearly shows that the most rapid gains in performance occur early in training, and then only gradually increase in later stages of training and practice. Thus measures that predict late performance may not predict early performance. Regain and Schneider stressed the importance of using predictors that tap the cognitive processes or knowledge required of the criterion task(s).

Marksmanship data also illustrate the concept of skill plasticity. While Dyer (1999) found relatively high correlations (0.50 to 0.67) between practice record fire and record fire for three sighting systems, the relationship between scores on one sighting system and another were minimal. Some Soldiers indicated that they were uncomfortable in using some of the sights, which were new to them, at this particular stage in training. A summary of correlations among the periods in basic rifle marksmanship training clearly shows that marksmanship skills in initial entry training are not stable until the later periods of instruction which involve record fire (Dyer et al., 2012). Rounds to group and zero, measures of performance in the earliest periods of instruction, did not correlate with each other or with later measures of performance.

Using Prior Knowledge as a Predictor for Tailoring Training

Clearly, there are challenges in finding measures that are "good" predictors of classroom performance. In a review of literature, Schaefer and Dyer (2012, 2013) argued that the best predictor is relevant prior knowledge. This conclusion was based on research that showed prior knowledge was a better predictor of job performance than general mental ability or measures of experience. The rationale for this finding was that "prior knowledge is in effect the combination of capacity to learn (general mental ability) wed to the opportunity to learn (experience)" (Schaefer & Dyer, 2013, p. 25). Thus experience only provides an opportunity to gain skills and knowledge, but does not guarantee it or provide that the appropriate skills and knowledge will be obtained or retained. Consistent with the findings by Regain and Schneider (1990), Glaser (1984) also stressed the importance of domain-specific prior knowledge and skills as critical to later achievement and learning. Relevance of prior knowledge is cited in the tutoring literature as well, being the primary means by which tutors could individualize their instruction and customize and elaborate on their explanations to individual students (Wittmer, Nuckles, Landmann, & Renkl, 2010).

Most of the research on using measures of individual differences to determine the best tailored training approaches (e.g., aptitude-treatment interactions (Corno & Snow, 1986; Schaefer & Dyer, 2012, 2013) has been conducted in public school or experimental settings. Aptitude-treatment interaction research has typically not been conducted extensively with adult students, particularly Soldiers. Thus it was important to determine what would be good predictors in Army courses to determine if the findings would replicate those in the literature and to determine lessons learned regarding how to develop and apply these measures.

Predictors of Performance in Army Courses

As part of the ARI tailored training research program, predictors of course performance were developed and examined for six efforts: Warrant Officer Candidate School, Engineer Captains Career Course (CCC), Infantry Advanced Leader Course, Mechanical Maintenance courses for the Abrams tank and Bradley Fighting Vehicle, and two marksmanship courses (Infantry One Station Unit Training, and Squad Designated Marksmanship Course). The results and lessons learned are summarized here as they provide the foundation for the Prior Knowledge Assessment Guide.

The first effort was with the Warrant Officer Candidate School (Schaefer, Bencaz, Bush, & Price, 2010). Instructors were interviewed to help identify what differentiated high- vs. low-performing students. Three characteristics were cited by instructors: initiative, attention to detail, and metacognition. Existing measures of initiative and metacognition were used. A special measure was developed to assess attention to detail. In addition, the demographic background of the Soldiers (e.g., education, years in service) was obtained as well as details on their prior life experiences. No specific prior knowledge instrument was used in this research. The criterion measure was the average of three academic tests given in the course.

Some of the experience variables related to the criterion measure, but not strongly. The individual difference variables suggested by the instructors did not relate to the criterion. The

authors felt that demographic variables still held promise as predictors, but that future efforts should focus on direct measures of prior knowledge, not instructor's recommendations of student characteristics.

With the Engineer CCC research (Schaefer, Blankenbeckler, & Lipinski, 2011), the criterion was a defensive planning test given as an integral part of the course. Five types of predictors were used. First, the small group instructors projected the officers' later performance (top 25%, middle 50%, and bottom 25%). Second, demographic or biographic data were obtained (e.g., education level, prior service as a noncommissioned officer, deployment experience). The officers also provided two self-reports. One was on their prior experience relevant to defensive planning (training, military experience). The other focused on their self-confidence in executing military activities related to defensive planning.

The fifth type of predictor was a prior knowledge test of defensive planning. The prior knowledge test was based on several factors including instructor input and review. It was designed to test more than facts. It also focused on the officers' ability to use information and apply principles and concepts, placing the officer in the role of a task force Engineer. The test included situational descriptions, and samples of documents which an officer might have in the field such as tactical diagrams, photos of opposing force engineer systems, and planning documents. Incorrect options were based on common errors. Perhaps more important, was that the research team had access to the defensive planning criterion measure. Consequently, they were able to better identify relevant prerequisite knowledge and understandings which should have been gained by the officers in prior military training, specifically the required Engineering Basic Officer Leader Course.

Findings showed that for officers with no prior enlisted experience, prior knowledge alone was a significant predictor ($r = .45$). In contrast, for officers with prior enlisted experience, there were no significant predictors from the battery of predictors. The authors speculated on the reasons for this difference, but did not reach a definitive explanation of the findings.

The research with the Infantry Advanced Leader Course (Schaefer, Blankenbeckler, & Brogden, 2011) was on predicting performance in two different blocks of instruction: a troop leading procedures (TLP) test and a land navigation field exercise. The predictors paralleled those used in the Schaefer, Blankenbeckler, & Lipinski (2011) research with the Engineer CCC. Predictors were small group instructors' prediction of performance, biographical data, personal prior experience in the two domains of interest (TLP and land navigation), and prior knowledge tests relevant to each criterion of interest.

The prior knowledge measure for TLP included items on TLP necessary for an offensive action, information on how a student would prepare to brief a squad, and an understanding of and ability to interpret symbols and graphics. The land navigation prior knowledge test was written, whereas the criterion was field performance. The written test included maps, photos, etc. Of particular interest was that the land navigation test included items on advanced orienteering skills, knowledge beyond what the noncommissioned officers would have typically learned during their previous military training and education. Some questions were included which had to be solved without a map, but typically are solved with a map. The intent of including such

questions was an effort to identify individuals who excelled on the land navigation performance criterion test. This was a first step in determining how to develop a prior knowledge test that could be used to identify high achievers.

For both domains, only the prior knowledge test correlated significantly with criterion performance, higher for TLP ($r = .40$ for TLP; $r = .28$ for land navigation). The attempt to identify high performers on the land navigation field test was only moderately successful based on an item analysis of the most difficult items on the prior knowledge test.

Predictors of performance in two vehicle mechanical maintenance courses, Abrams tank and Bradley Fighting Vehicle were examined in another effort (Cobb, Schaefer, Stallings, Blankenbeckler, & Wampler, 2014). The criterion in each course was the average percentage of "GOs" received on a series of tests in each course. Four types of predictors were used. One was a Soldier questionnaire tapping relevant prior experience with electronics and vehicle maintenance. The General Technical (GT) scores from the Armed Services Vocational Aptitude Battery (ASVAB) were obtained from student records. Three cognitive measures from the Educational Testing Service kit (Ekstrom, French, Harman, & Derman, 1976) were selected: Following Directions (integrative processes), Building Memory (working, visual memory), and Choosing a Path (spatial scanning). These had some face validity for tapping the cognitive processes involved in the mechanics training. Prior knowledge of basic electrical circuits and symbols was also assessed. These technical prior knowledge items were developed by an experienced instructor, not by the research team as in the prior ARI research efforts.

For each course, the only significant correlate with the criterion measure was prior knowledge ($r = .22$ for Abrams course; $r = .39$ for Bradley course). It should be noted that prior knowledge did not correlate with the criterion in an experimental version of the Bradley course, and the correlations among the predictor measures (experience, GT and prior knowledge) were consistent with the model developed by Schmidt, Hunter, and Outerbridge (1986), although the magnitude of the correlations were lower. The authors noted that the criterion, based on Go/NoGo dichotomous scores, was restricted in range, which typically results in attenuated correlations.

There were at least two lessons learned from the vehicle maintenance effort. The first is the importance of having a criterion measure that is sensitive to individual differences in performance levels. Go/NoGo or Pass/Fail measures are not sensitive to differences in individual performance. The second lesson learned is that experienced instructors can develop measures of relevant prior knowledge based on their experience with students in prior courses. They have a "good understanding of the basic skills that are most relevant to critical learning objectives and enable students to excel in training" (Cobb et al., 2014, p. 34). They also know the criteria for performance in the course, providing them with insight and a unique perspective regarding the prerequisite knowledge requirements for their course.

The last effort (Lipinski, James, & Wampler, 2013) focused on marksmanship skills with the criterion being hands-on performance, but the predictors were paper-pencil tests. With this research the major purpose was to determine whether performance on a prior knowledge test of marksmanship added any predictive power beyond that from simply asking if Soldiers had

shooting experience outside of the military. One course was the Squad Designated Marksmanship (SDM) Course, which is typically attended by NCOs who have several years of service in the Army. In this case, the average time in service was 8 ½ years. The other course was Basic Rifle Marksmanship (BRM) taken by Soldiers in Infantry One-Station-Unit Training (i.e., "basic" training). Thus the Soldier samples were quite different in terms of military marksmanship experience. However, the predictor measures were the same for each sample: demographic information on marksmanship experience outside the military and a prior knowledge test which had two versions, a short form (nine matching questions) and a long form (the nine matching questions along with 16 multiple-choice questions). The test required students to match descriptive definitions with doctrinal terms and to indicate their understanding of ballistics, minutes of angle, iron and optical sight use, and the effects of wind on the trajectory of the bullet. Lastly, because of differences in the courses, the criterion live-fire measures also differed. The authors found that prior knowledge significantly predicted marksmanship performance beyond any effects of self-reported prior shooting experience. However, the relationship was much stronger for Soldiers in the SDM course (for both forms of the prior knowledge test) than for those taking BRM (correlations in SDM were typically greater than .30 with the highest being .65 vs. correlations being less than .25 in BRM).

There are three lessons learned from the marksmanship research effort. First, a prior knowledge assessment can be short and still be effective in predicting later performance. Second, a prior knowledge test should actually assess what is assumed to be prior knowledge. A very likely reason for the difference in the two samples was that the prior knowledge test did not, in reality, assess prior knowledge for the Infantry trainees, as it covered content which is actually trained in basic rifle marksmanship, advanced rifle marksmanship, and even specialized shooting courses. A comparison of the means on the test for the two groups showed that the Infantry trainees scored much lower, indicating their level of prior knowledge was less than those enrolled in the SDM course. Third, the results support prior findings regarding prior knowledge tests being better predictors than questions on experience.

Lessons Learned from the ARI Research on Predicting Performance in Army Courses

In summary, in each of the six efforts conducted as part of the ARI's tailored training research, a diverse set of measures was used as potential predictors of performance in a variety of Army courses (different subject matter) and with Soldiers of differing ranks and experience. Measures of relevant prior knowledge, used in five of the six efforts, were the only consistent significant correlate of course performance. Paper-pencil measures of prior knowledge also predicted hands-on performance, although one would expect a hands-on prior knowledge measure to be a higher correlate. Instructors' estimates of student performance, prior military experience, standardized cognitive measures, and non-cognitive measures did not predict. It is acknowledged that the prior knowledge correlations were not always high, but they were consistent. We knew from prior research (Dyer, Wampler, & Blankenbeckler, 2011) that instructors did not frequently use formal or systematic techniques to identify students with minimal knowledge or those with much prior knowledge. They would informally query some students about their military experience in order to identify those who might excel in the course and those who would have difficulty. But as determined in the prior efforts, systematic measures of military experience did not predict well, if at all.

In all but one of the ARI efforts, the prior knowledge tests were developed by the research team, in conjunction with or reviewed by instructors or course managers since the researchers lacked content expertise. On the other hand, while experienced instructors demonstrated they could apply their expertise to identify what key subject areas should be in a prior knowledge test, they needed significant assistance in how to develop "good" tests, as most did not have training in educational measurement. In addition, most instructors have not had any statistical training on how to relate prior knowledge data to criterion performance data. Both test development and some basic statistical skills are necessary to make decisions about which students might benefit most from tailored training. These factors necessitated a guide be developed providing instructors with the tools needed for test development and application.

Enabling instructors to develop prior knowledge assessments also means that in-house resources will be used. A research team does not need to be "called in" nor is there a need to search the literature for measures or possibly pay a cost for a generic predictor measure.

Another advantage of prior knowledge assessments is that they have "face" validity. Students don't wonder "Why am I taking this?" and an instructor can easily explain the relationship between prior knowledge and the ease of learning new information and skills.

The research also showed the importance of using criterion measures that are sensitive to individual differences. Although the research did not examine the extent to which prior knowledge assessments predicted course performance at different points in time, the plasticity of skill learning was acknowledged in the guide. One effort also demonstrated the importance of clearly defining/conceptualizing what is meant by "relevant prior knowledge" in a course. Experienced instructors know the student populations and their prior formal military training. If a prior knowledge assessment is based on knowledge to be learned in the course or learned in future courses, then, by definition, it is not prior knowledge and predictions will be minimal at best. The next section in the report describes the concept of relevant prior knowledge in more detail.

Assessing Prior Knowledge

The key to assessing prior knowledge as a predictor is to assess relevant prior knowledge. In general, prior knowledge, as it relates to military training, is any knowledge a student has prior to beginning training. Thus, a student's prior knowledge can consist of knowledge in many different knowledge areas. For purposes of military training, a knowledge area is factual information directly related to some particular area of interest or requirement in a training program or course, as well as knowledge on specific equipment and skills associated with that area. However, not all prior knowledge is directly relevant to the specified training to be conducted. When prior knowledge possessed in any specific knowledge area is applicable to enhancing success in subsequent training, that knowledge is considered relevant. An instructor must determine exactly which knowledge areas have a potential influence on planned training outcomes and if prior knowledge within those areas enhances a student's ability to perform well during training. Clearly, not all of a student's prior knowledge meets these criteria. For example, relevant prior knowledge for tracked vehicle mechanics training is likely different from what prior knowledge would be relevant for radar systems operator training. Also, prior

knowledge of basic mechanical tools and how they are used is important for training in a technical mechanics course, while knowledge of how to splint a broken leg or interpret compass readings is irrelevant for maintenance tasks. Instructors must understand the breadth and content of different knowledge areas as they relate to any specific training course.

In the guide presented in this report, a prior knowledge assessment is a tool that measures students' levels of relevant knowledge, rather than just collecting general information on students' backgrounds and experiences. This data should allow users to forecast students' probable performance during training.

Prior knowledge assessments differ from pretests. Like pretests, prior knowledge assessments are administered prior to, or at the start of, training and often consist of paper-based or hands-on evaluations of student knowledge and/or skills. Pretests however, determine how much knowledge a student currently possesses of the course content; thus, questions on pretests assess knowledge about what is to be taught in the course. Also, most pretests will include test items identical to or very similar to those on a "posttest" or "final exam." On the other hand, prior knowledge assessments measure associated knowledge areas that will aid students in their learning experience, but do not directly assess knowledge about specific material or content to be taught in the course. For example, prerequisite knowledge and skills are considered relevant prior knowledge.

Each prior knowledge assessment should be unique to the course or block of instruction for which it was designed. Most often, instructors are in the best position to determine what specific knowledge areas are most relevant for their training course and to training success. From past training, they are aware of prior knowledge deficits exhibited by students which negatively impact learning as well as acquired knowledge areas that greatly facilitate learning. Once a determination of what knowledge areas are relevant, an assessment must be obtained or developed to measure the extent to which students possess that knowledge. Since such assessments most often do not exist, they must be developed. In the case of vehicle maintenance training, development of an assessment would likely include questions in related knowledge areas such as those regarding the identification and use of common vehicle maintenance tools. It might also include questions addressing applicable content in other relevant knowledge areas such as basic knowledge on electricity and wiring.

Problem Definition

The overall intent of this effort was to assist Army instructors in identifying, at the start of training, candidate students to receive some type of planned tailored training. The problem facing instructors today is that although relevant prior knowledge may be a predictor of future classroom performance, assessing the level of prior knowledge in students can be challenging. Consider the following:

- Prior knowledge can help predict future performance in the classroom;
- Prior knowledge must be relevant to the training conducted;
- Levels of relevant prior knowledge in individual students correlate with performance;
- An assessment is required to identify student levels of relevant prior knowledge;

- Assessments must be unique in measuring levels of prior knowledge relevant to the training to be conducted;
- Unique assessments most often do not exist and must be developed;
- Currently Army course managers, training developers, and other academic personnel are largely not trained on how to develop unique prior knowledge assessments; and
- Army personnel are also not trained on how to apply assessment results to identify potentially weak and/or strong students.

It is worth noting that predicting student performance in some Army training situations might be less beneficial than in others. Specifically, training intended primarily to "familiarize" students with information and overall concepts generally does not rely on tailoring to achieve training goals. Therefore, developing prior knowledge assessments for general familiarization training would not be worth the effort. However, students in more technical or extended training courses, portions of courses, or specific blocks of training that require formal standards of proficiency generally benefit most from tailored training. Assessing prior knowledge in these training situations would make it much easier to effectively tailor training to different students.

Development of the Prior Knowledge Assessment Guide

Development Method

This effort was conducted in order to produce a Prior Knowledge Assessment Guide, a copy of which is provided in the Appendix. Titled "Guide for Developing and Using Prior Knowledge Assessments to Tailor Training," the guide assists academic personnel in the creation of a tool to help identify, at the start of training, students who would benefit from training that is tailored to their needs. The specific purpose of the guide is to assist training personnel in creating and validating prior knowledge assessments, and to enable them to use the results to identify students who would benefit from tailored training. It specifically provides guidance on how to develop assessments in order to identify:

- Students who may need additional assistance due to a lack of or minimal amount of relevant prior knowledge, ***and/or***
- Students who could benefit from additional challenges due to their familiarity and understanding of requisite knowledge.

The guide needed to provide sufficient guidance on developing prior knowledge assessments, determining their validity, and on using assessment results to identify students who could potentially benefit from tailored training. It is acknowledged that the "validation procedures" cited in the guide are not equivalent to those used in the development of widely-used tests. From the viewpoint of a psychometrician, they would probably be considered necessary but not sufficient.

The decision was made to develop the guide with the idea that users will not need a detailed background on why prior knowledge assessments should be used for predicting student performance. Our initial assumption was that users would already have made the decision to

create a prior knowledge assessment and the guide would simply walk them through how to effectively do that. Based on this, it was determined that only limited background information in the introductory portion of the guide would be provided in order to set the conditions for the rest of the guide.

Development of the guide began with an examination of available research efforts on assessing prior knowledge. The literature review included additional information available from the academic community. An analysis of all information gathered provided a basis for the upfront portion of the guide which identifies how prior knowledge assessments can be used and what type of prior knowledge is considered relevant. Additional research involved identifying applicable sources to be used as guidelines for developing assessment questions. Finally an examination of potential methods for use in validation of assessments was conducted to determine the most practical means for performing correlation coefficient computations for potential developers.

Guide Content

The guide was developed along the lines of what users would need to know to develop and validate a prior knowledge assessment. Along with a short introduction in Chapter 1 that provides some basic background information and sets conditions for the remainder of the guide, it was determined that three additional chapters would be required to explain the main topics including development, validation, and use of prior knowledge assessments. The chapters are sequenced in the order they would likely be used. Supplemental information and developmental exercises are included in appendices.

Chapter 1. Chapter 1 provides an overview of prior knowledge assessments and lists key terms and definitions used throughout the remainder of the guide. Key terms and definitions are presented due to the differences in term definitions found throughout literature and to provide a basis for users unfamiliar with associated terms and concepts.

Chapter 2. Chapter 2 describes how to develop a prior knowledge assessment to fit the user’s needs. It provides a detailed step-by-step set of instructions for developing a prior knowledge assessment tailored to a specific course or block of instruction. The five developmental steps are shown in Table 1.

Table 1
Process for Developing a Prior Knowledge Assessment

Development Steps		Scope
Step 1	Determine what instruction will include tailored training	• What instruction will be tailored? o Entire training course? o Specific blocks of instruction?
Step 2	Determine which students will receive tailored training	• What type of tailored training is envisioned? o Additional assistance for students likely to struggle. o Additional challenges for students likely to excel. • How will the results of the assessment be used to tailor training? o Identify students with little or no relevant prior knowledge. o Identify students with much relevant prior knowledge. • What determines a low/high performer during training?
Step 3	Determine what prior knowledge areas to measure	• What knowledge areas are relevant to the training? • Will these knowledge areas affect the student's learning experience, particularly initial learning?
Step 4	Identify the specific content for each prior knowledge area	• What specific content will be assessed in each knowledge area? o Identify the specific content to assess within each knowledge area; and o Identify content that best defines desired student knowledge levels and understanding of selected knowledge areas.
Step 5	Develop the questions for the prior knowledge assessment	• What questions should be asked? o Use information from Step 4 for content. • What type of assessment will be administered? o Hands-on, paper-based. • How many questions for each knowledge area? o Emphasis/time allotted per knowledge area during training. • What question formats will be used? o Multiple-choice, True-False, Matching. • What cognitive level of understanding will be sampled by the questions in each knowledge area? o Knowledge, comprehension, application. • How difficult should be the questions in each knowledge area? o Easy, hard, complex. • How will the assessment be scored?

Each of the developmental steps is discussed in detail with examples added to provide clarity for the information and topics addressed. This chapter provides the information necessary for users to understand the importance of designing prior knowledge assessments in a way that helps identify the students targeted and around knowledge areas that are relevant to the instructional material. It further provides numerous examples of questions and types of questions to assist users in formulating questions for their assessment. The five steps were constructed in a logical, sequential manner in order to ensure the user was not only aware of the significance of the actions involved in each step but that each action was accomplished in the proper sequence. The following list identifies the reasoning for each of the five steps.

- Step 1. Prior knowledge assessments are unique to the instruction to be delivered. As such, Step 1 has users identify what instruction the assessment will be used for prior to beginning development.
- Step 2. This step encourages users to have a clear understanding of what they intend to accomplish by using a prior knowledge assessment before they begin development. Without this understanding those developing the assessment will find it hard to continue with the following steps.
- Step 3. The selection of knowledge areas is vitally important to creating an applicable, valid prior knowledge assessment. Without the proper identification and selection of knowledge areas, the assessment will not be valid and any data obtained from the assessment will not identify the appropriate students.
- Step 4. Once the knowledge areas are identified, users must decide what information from each area would best represent how familiar a student is with the associated facts, concepts, and skills it contains. Since knowledge areas can sometimes tend to be broad in nature, developers need to consider what information within each area is potentially most relevant to the training of interest before beginning to formulate assessment questions.
- Step 5. The final step involves the actual development of questions that will be on the assessment. Personnel developing these assessments very likely have never had any formal training on test development or formulation of test questions. In that light, the discussion for this step provides question development guidance and includes examples of poor and good questions while highlighting the dos and don’ts of each type of question and the associated potential development issues.

Chapter 3. Chapter 3 describes the process of validating a prior knowledge assessment. The validation process presented involves determining the degree to which the prior knowledge assessment predicts (correlates with) the course criterion measure. It includes why validation is necessary, what information is needed in order to validate an assessment, and the steps required for performing validation. The chapter begins with a discussion on what validation means and why it is necessary. This chapter also includes information on selection of the criterion measure and the issues associated with that choice (e.g., when it is administered, the sensitivity of the criterion). This discussion was included to reinforce that it is vitally important for users to understand the need for validating an assessment. Without that understanding, users may feel that an assessment they spent hours working on is a good product and may be tempted to use it without validation. Since assessments are only as good as their ability to predict outcomes to an acceptable degree, using assessments without validation will likely not highlight the students it was designed to identify.

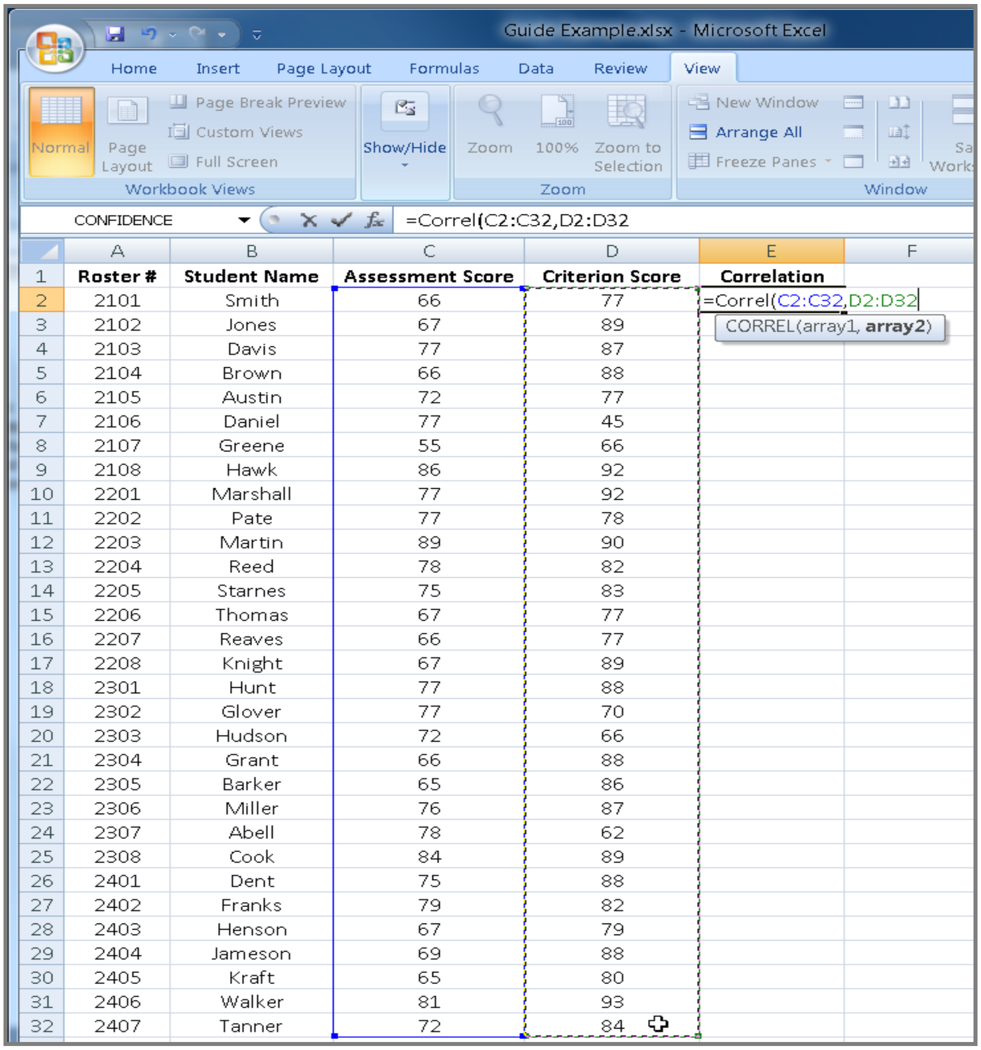
The guide also emphasizes that predictions involve some degree of error; that the relationship between prior knowledge assessment scores and criterion scores is not perfect. The degree of risk in predicting who will do well in a course and/or who will have difficulties is reduced as the strength of the relationship increases between the prior knowledge assessment and the criterion scores. This concept was integrated in the guide so users will have realistic expectations about their predictions for individual students.

It is likely that users may not be familiar with Excel or the mathematics that underlie correlation coefficients. Since validation includes both, the steps for validation explain in detail the process of using these tools to validate an assessment. The steps provide a procedure with sufficient detail to allow a user to validate an assessment even without a complete understanding of the theory behind the mathematical calculations. Each of the validation steps, shown in Table 2, is explained with corresponding screenshots of Excel spreadsheet procedures for data input and manipulation.

Table 2
Prior Knowledge Assessment Validation Steps

Validation Steps	
Step 1	Administer the Prior Knowledge Assessment • Administer the assessment; • Instructor does not see the results; • Instructor conducts training as usual; and • Collect criterion scores after training.
Step 2	Obtain and Input data into an Excel spreadsheet • Obtain student names and/or roster numbers, prior knowledge assessment scores, criterion measurement scores; • Create an Excel spreadsheet; • Record three sets of data in the spreadsheet (name/roster number, assessment score, criterion score); and • Check all data for accuracy.
Step 3	Compute a correlation coefficient • Create correlation coefficient formula in the spreadsheet; and • Compute the correlation coefficient.
Step 4	Evaluate the strength of the relationship between the two scores • Determine if the relationship is strong enough to support using the prior knowledge assessment to tailor training.
Step 5	Plot the relationship between the two scores • Create scatter plot in Excel using input data; and • Examine the scatter plot for outliers and strength of the relationship.

The Excel screenshots, such as the one in Figure 1, are provided for clarity in the guide with the assumption that all users may not be equally familiar with using Excel software for data management and analysis. The screenshots and accompanying discussion provide easy to follow instructions that even novice users can understand. Even if users do not understand the concept behind correlation coefficients, by following the step-by-step validation process provided in the guide, they can still properly validate an assessment.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	=Correl(C2:C32,D2:D32	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		

***Figure 1*.** Excel spreadsheet example.

Chapter 4. Chapter 4 focuses on using and revising prior knowledge assessments. Once validation has been attempted a prior knowledge assessment will either be found acceptable for use or not. In either case, users need to know what to do with it next. This chapter explains both. For validated assessments, this chapter explains how to establish cut points for identifying students for tailored training followed by administrative procedures for using the assessment in subsequent training. Procedures for identifying students who may need help as well as those who need to be challenged are presented. This is the critical application of the prior knowledge assessment after its validation. For assessments that were not validated, this chapter identifies possible contributing reasons and suggestions for revising the assessment in order to increase the chance of it being validated.

Assessment of the Guide

Assessment Method

The purpose for obtaining feedback on the Prior Knowledge Assessment Guide was to gain, from a potential user perspective, comments on its content, organization, clarity, ease-of-use, readability, and understandability. Reviewers were asked to read through the guide from the perspective of a potential user while focusing on whether or not it provides clear guidance on developing, administering, and validating prior knowledge assessments.

Pilot Assessment

An initial pilot assessment was conducted with a small group of potential users. The purpose of the pilot assessment was to obtain feedback on the guide as well as feedback on the assessment materials developed to record participant reactions and comments. The pilot assessment was conducted with four instructors from the Ordnance Mechanical Maintenance School, Fort Benning GA, which provides advanced individual training for Soldiers in Armor and Bradley maintenance specialties. Responses were overall favorable which resulted in very minor changes to the guide and no changes to the assessment materials.

Revised Guide Review

The revised guide was subsequently provided to an experienced training cadre and personnel assigned to the Infantry Mortar Leader Course, Fort Benning, GA, and the Warrant Officer College, Fort Rucker, AL. All personnel (N = 9) who provided feedback on and recommendations for revising the guide were experienced instructors, training developers, course managers, training team chiefs, or other training subject matter experts. Thus, each reviewer represented the intended population of potential users of the guide. In addition to obtaining written feedback, some reviewers (N=3) were available for an informal discussion which provided clarification and amplification on the responses of all reviewers from their respective organizations.

Assessment Feedback Form

An assessment form was generated to solicit feedback from supporting reviewers. The questions were designed to obtain perspective users' impressions of the guide in providing the material in a manner that allows users to create and validate a prior knowledge assessment. The request for feedback did not require or ask for reviewers to create a prior knowledge assessment. The intent was only to gain potential users' impressions of whether or not they believed they could develop and validate a prior knowledge assessment using the guide.

Assessment Feedback

An analysis of the scores for each of the feedback questions and the accompanying written comments indicated that feedback could generally be categorized into two groups: foundational or core-level instructors and senior level academic personnel including senior

trainers, training managers, and other senior academic personnel. General feedback indicated that while the guide was a well written, informative set of guidelines for creating a Prior Knowledge Assessment, it included some concepts that were challenging to understand and implement for some lesser experienced readers.

Based on the feedback we received, junior level instructors tended to be overwhelmed with the amount of information in the guide and with some of the unfamiliar concepts, such as completing an assessment validation. Comments stemming from follow-on discussions with these indicated they generally prefer information in the form of short, step-by-step instructions for completing the task at hand. As described in the guide, development of a Prior Knowledge Assessment for a particular course requires higher level reasoning and decision making on the part of the developer in order to create an assessment for validation. Thus, steps within the guide include the rationale for key decisions with an explanation of what must be accomplished. Decisions regarding assessment content and structure can be challenging for less experienced personnel but ultimately rest in the training developer's hands. Many junior level instructors appeared reluctant to stray from the familiarity of the instructional concepts and approaches they have been taught. In addition, verbal feedback from follow-on discussions with instructors who participated in this effort also indicated that junior instructors tended to base their perceptions of likely student performance on personal observations alone.

More senior personnel, e.g. course managers and senior instructors, readily saw the value in the guide and in using Prior Knowledge Assessments. Their response to the guide was largely positive with virtually no major issues in wording, understanding, organization, and content. Some feedback from senior personnel acknowledged that they believed junior instructors may have difficulty in using the guide were they to attempt to design a Prior Knowledge Assessment.

Comments suggested two specific additions to the guide. First, reviewers recommended including a glossary and index similar to what would be found in a text book. Second, they recommended adding something similar to a quick start set of instructions that highlights the main steps in developing a prior knowledge assessment.

Final Revision

Ultimately the feedback we gathered resulted in two changes to the guide. Initially the guide was designed for use by instructors, training developers, course managers, or other training personnel. Correspondingly, verbiage in the guide originally used the term "instructors" to encompass all potential users including instructors. The decision was made to narrow the focus of potential uses to senior level instructors and other senior training personnel, including course managers and training developers, with input from junior level instructors, as appropriate. The term "developer" replaced references to "instructor" to encompass these personnel and more closely reflect the likely potential users of the guide.

Secondly a "Quick Reference Prior Knowledge Assessment Development and Validation Flowchart" was developed and included as an Appendix in the guide. The updated guide, to include flowchart, is attached as the Appendix to this report. It was determined that the inclusion of the flowchart would accomplish the main intent behind the suggestion for an index

and add a reference for users to assist them during assessment development. While an index would only direct a user to locations of specific words within the guide, the flowchart directs them to specific concepts and steps in a logical sequence. The flowchart begins with a developer's decision to create a Prior Knowledge Assessment and systematically directs the user step-by-step through the process. Each step includes the page and paragraph number where information regarding that step can be found in the guide. A separate glossary was determined not to be necessary as a "Key Term Definitions" section is included in Chapter 1.

Conclusions

Any typical training situation will likely have students who will excel in training as well as those who will be more challenged to learn the content in the time available. Either of these groups could benefit from some type of tailored training, but identifying students in these groups often becomes clear only at some point during or at the completion of training. In order to effectively tailor training to meet students' needs, instructors must be able to identify their relevant strengths and weaknesses as close to the start of training as possible. The Prior Knowledge Assessment Guide was designed to help identify students who could benefit from tailored training. Instructions in the guide can be used by developers to assist instructors in establishing a basis for tailoring training in Army courses through the use of prior knowledge assessments.

Collectively, research prescribes that prior knowledge, as a variable, may be used to predict performance as it has in its roots aspects of performance related skills, mental abilities, and experiences. In contrast, mental ability and prior experience, either independently or combined, have been shown to be poor predictors of later performance (Dokko, Wilk, & Rothbard, 2009). Recent research in several Army courses supports this finding as well. Although prior knowledge has been shown to correlate well with subsequent student performance, using prior knowledge as a predictive measure for Army training applications requires a means for measuring that knowledge in individual students. Since prior knowledge is often unique to some specific course content, prior knowledge assessments must also be unique to each course. Moreover, since these assessments do not often exist, they must be developed in order to measure the extent to which students possess relevant prior knowledge. Generally, Army training personnel are not equipped with the necessary information and skill they need to create and validate assessments that meet their needs. The intent of developing this guide was to provide information that would allow for the development of an assessment uniquely tailored to the training for which it would be used.

Feedback on the ease of use, clarity, readability, understandability and completeness of the guide was largely positive, while also indicating that the personnel most likely to use the guide to develop assessments would be senior level training personnel. While junior level instructors can be a great resource in identifying appropriate knowledge areas and content for specific assessment questions, they are not likely to be the personnel actually developing these assessments. Senior level instructors, course managers, training developers, or other senior level training personnel will generally develop the assessments to assist instructors.

The guide will be most useful in training situations where students are taught technical procedures that require formal standards of proficiency where tailored training can be more appropriately applied to meet individual student needs. Instructors who provide training intended primarily to "familiarize" students with information will find the guide less useful. Similarly, higher level courses that do not teach technical skills but rather seek to exercise students' cognitive skills, such as assessing situations and information, formulating opinions, and drawing conclusions, may find it much more difficult to develop an effective Prior Knowledge Assessment. However, these training personnel may still benefit from the guide, as it does describe a logical, sequential thought process for evaluating prior knowledge as it relates to subsequent student performance.

This guide can be used by any TRADOC training institution wishing either to develop Prior Knowledge Assessments to predict student performance or to gain a better appreciation of how prior knowledge can potentially affect training in their classrooms. This guide will be of most benefit to training developers, course managers, and other senior level training personnel who are seeking a step-by-step set of instructions on how to develop, validate, and apply the results from a Prior Knowledge Assessment to identify students who would benefit from planned tailored training.

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GUIDE FOR DEVELOPING AND USING PRIOR KNOWLEDGE ASSESSMENTS TO TAILOR TRAINING

United States Army Research Institute
for the Behavioral and Social Sciences

Fort Belvoir, Virginia

Preface

This guide assists training personnel in identifying, at the start of training, students who would benefit from training that is tailored to their needs. The specific purpose of this guide is to assist those personnel in creating prior knowledge assessments by describing how to develop unique questions tailored to their specific courses' content and goals. It specifically provides guidance on how to develop assessments of a student's relevant prior knowledge in order to identify:

- Students who may need additional assistance due to a lack of or minimal amount of relevant prior knowledge, ***and/or***
- Students who could benefit from additional challenges due to their familiarity and understanding of requisite knowledge.

This guide focuses on the assessment of relevant prior knowledge because such assessments have been shown to predict how individual students will perform during training. Assessing prior knowledge is more reliable than other techniques that might be used such as subjective judgments, personality measurements, or demographic information. Sufficient guidance is provided in the guide to enable personnel to develop these prior knowledge assessments, to determine their validity, and then how to use the assessment results to identify students who could potentially benefit from tailored training.

This guide **does not** explain how to tailor training. Instead it provides a starting point for those who want to tailor their training by providing guidance for developing assessments to identify which students would most likely benefit from training that is tailored to their level of prior knowledge.

Examples used within this guide are intended as illustrations and clarifications of the topics discussed. Rather than limiting all the examples to a single content area or training environment, a variety of examples are used to further illustrate specific points and reflect different training contexts.

The intended audience for this guide is training developers, course managers, senior level instructors or other personnel likely to develop Prior Knowledge Assessments. Within this guide, the term "developers" is used to encompass all potential users.

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APPENDICES

Chapter 1. Introduction

This guide is designed to help you, the developer, assist instructors in establishing a base for tailoring training in Army courses through the use of prior knowledge assessments. Any typical training situation will likely have students who will excel in training as well as those who will be more challenged to learn the content in the time available. Either of these groups could benefit from some type of tailored training, but identifying students in these groups often becomes clear only at some point during or at the completion of training. In order to effectively tailor training to meet students' needs, instructors must be able to identify their relevant strengths and weaknesses as close to the start of training as possible.

Often, experienced instructors begin a course with an idea of how they plan to tailor training but are challenged to determine, with any significant confidence, which students their planned tailoring would most benefit. For example, if the instructor wants to tailor training to focus on the needs of weaker students, tailoring cannot be implemented without knowing which students should receive it. To help make that determination, an early assessment of students' prior knowledge can give the instructor some idea of those most likely to struggle with the content. Assessments that provide insights into students' relevant prior knowledge levels can help predict who are most likely to perform either above or below average during the course. This information enhances the instructor's ability to target the right students to receive the tailored training envisioned. It does not however, provide assistance in how tailoring should be accomplished. Instructors must decide how they plan to implement tailoring to the identified students as a variety of methods may be used.

It is worth noting at this point, that predicting student performance in some Army training situations might be less beneficial than in others. Specifically, training intended primarily to "familiarize" students with information and overall concepts is generally not demanding and does not rely on tailoring to achieve training goals. Therefore, developing effective prior knowledge assessments for general familiarization training would not be worth the effort. However, students in more technical or extended training courses, portions of courses, or specific blocks of training that require formal standards of proficiency generally benefit most from tailored training. Assessing prior knowledge in these training situations would make it much easier to effectively tailor training to different students.

1.1 Overview of Prior Knowledge Assessments

In this guide, a knowledge area refers to factual information directly related to some particular area of interest or requirement in a training program or course, as well as knowledge on specific equipment and skills associated with that area. As an example, knowledge and skills relating to the identification and use of a set of basic mechanical tools could be described as one knowledge area, while knowledge relating to maps and map reading could be described as another knowledge area.

What is Relevant Prior Knowledge?

Prior knowledge, as it relates to military training, is any knowledge a student has prior to beginning training. When the prior knowledge possessed in any specific knowledge area is applicable to enhancing success in subsequent training, that knowledge is considered relevant. At some point, it must be determined exactly what knowledge areas have a potential influence on planned training outcomes and if prior knowledge within those areas enhances a student's ability to perform well during training. Clearly, not all of a student's prior knowledge is relevant or will potentially influence later training experiences or success. More than one knowledge area may be relevant to a particular course or block of instruction. For example, relevant prior knowledge for tracked vehicle mechanics training is likely different from what prior knowledge would be relevant for radar systems operator training. As the developer you, along with the instructor, must understand the breadth and content of different knowledge areas as they relate to any specific course.

In order for prior knowledge to predict or relate to later performance, there must be a reasonable conclusion that students possessing knowledge in those areas will do better in training as a result of having that knowledge. As an example, suppose your course is preparing to teach a new group of wheeled vehicle mechanics how to perform maintenance on a selected vehicle. Instructors may want to first determine which students actually know and understand the use of the basic mechanical tools required to perform those operations. Understanding the differences between and the use of various tools is relevant prior knowledge and necessary in order to perform more complicated maintenance tasks. Whether or not students can properly splint a broken leg or interpret compass readings are irrelevant for performing core maintenance tasks. Without a basic understanding of tools and their use, a student will have a tough time performing even basic maintenance procedures. Therefore an assessment would likely include questions regarding the identification and use of common vehicle maintenance tools for that specific knowledge area. It might also include additional questions addressing applicable content in other relevant knowledge areas such as basic knowledge on electricity and wiring. Most often, training developers, course managers, and instructors are in the best position to determine what specific knowledge areas are most relevant to training success.

What is a Prior Knowledge Assessment?

A prior knowledge assessment is a tool that measures students' levels of relevant knowledge, rather than just collecting general information on their backgrounds and experiences. This data should allow you to forecast students' probable performance during training. Prior knowledge assessments differ from pretests. Like pretests, prior knowledge assessments are administered prior to, or at the start of, training and often consist of paper-based or hands-on evaluations of student knowledge and/or skills. Pretests however, determine how much knowledge a student currently possesses of course content; thus, questions on pretests assess knowledge about what is to be taught in the course. Also, most pretests will include test items identical to or very similar to those on a "post test" or "final exam". On the other hand, prior knowledge

assessments measure associated knowledge areas that will aid students in their learning experience, but do not directly assess knowledge about specific material or content to be taught in the course. For example, prerequisite knowledge and skills are considered relevant prior knowledge.

It is important to understand that using an assessment to measure an individual's prior knowledge is only a measurement that estimates the level to which that individual possesses that knowledge. As such, assessments are subject to errors both in measuring the actual level of knowledge as well as in their indications of future student performance. When using assessments designed for predictive purposes, you need to be aware of these limitations and should not expect a measurement or prediction to be perfectly accurate.

Where Do I Get My Prior Knowledge Assessment?

A prior knowledge assessment is specific to the course or block of instruction for which it was designed. It is not a general test of knowledge. Once you determine what prior knowledge areas are relevant, you must either obtain or develop the appropriate assessment. Since such assessments typically do not exist, this guide helps you develop them. The instructions in Chapter 2 (Developing Prior Knowledge Assessments) give you the information you need to move forward.

What Do I Do With My Prior Knowledge Assessment?

Once a prior knowledge assessment is developed, the next step is to determine if it accomplishes the purpose for which it was designed. To accomplish this, the assessment must be validated to determine how well it predicts either low or high performers depending on its intended use. Validation occurs through an analysis of the assessment results as compared to a criterion indicating actual student performance after training. This analysis indicates how well the results on the prior knowledge assessment predicted actual course performance. Chapter 3, *Validating Prior Knowledge Assessments*, provides details on how to accomplish this validation along with information on what the comparison results mean.

Once an assessment has been validated, the assessment may be used in subsequent classes to assist in tailoring training. In such cases, the assessment should be administered prior to or at the start of training, its results examined, and training tailored to the identified students as envisioned. Chapter 4, *Using and Revising Prior Knowledge Assessments*, contains information on how to administer a prior knowledge assessment.

1.2 Key Term Definitions For This Guide

For clarity and consistency, the following terms and their associated definitions are provided *as they apply to the content in this guide*.

- **Knowledge Area** - Knowledge relating to some particular area of interest; contains factual information as well as knowledge on associated equipment and skills in that area.
- **Prior Knowledge** - Any knowledge a student has prior to beginning training.
- **Relevant Prior Knowledge** – Knowledge a student has prior to beginning training in areas determined to have a positive influence on associated training outcomes; knowledge that would likely enhance a student's ability to perform well during the training.
- **Prior Knowledge Assessment** - A tool that generates data quantifying students' levels of relevant prior knowledge; administered prior to or at the start of training.
- **Validation** – A process for determining how well a prior knowledge assessment predicts later performance in the course.
- **Criterion** - A measurement of actual performance after training as related to course objectives.
- **Performance** - An inclusive term encompassing knowledge, skill, and hands-on abilities demonstrated during training.
- **Correlation** - A statistical analysis determining the relationship between two variables, which in this case are scores on the prior knowledge assessment and actual student performance as indicated by a criterion measurement after training.

1.3 Information Included in This Guide

The remainder of the information included in this guide will provide:

- Guidance on how to develop a prior knowledge assessment
- Guidance on how to confirm if a prior knowledge assessment meets the needs for which it was designed
- Additional information on other actions pertaining to the development and administration of prior knowledge assessments
- Quick Reference Prior Knowledge Assessment Development and Validation Flowchart (Appendix A)
- Sample exercises for practice/assistance in associated Excel based calculations (Appendix C)

Chapter 2. Developing Prior Knowledge Assessments

Instructors wishing to use prior knowledge assessments to tailor training face a number of challenges, including the availability of the assessments themselves and the time needed to conduct an assessment. Prior knowledge assessments are generally not available and must be developed from scratch. Additionally, the time needed for administering prior knowledge assessments is often not in the course schedule. However, properly developed assessments can be administered fairly quickly with minimal disruption of training. The remainder of this chapter provides you as the developer assistance in creating prior knowledge assessments to assist instructors in meeting their needs of student identification for tailored training.

2.1 How Do I Develop a Prior Knowledge Assessment?

Using a structured approach will help streamline the process and ensure the assessment supports the instructor's needs. The steps presented in Table 1 use a backwards planning approach for development. The process encourages you to first understand the purpose behind the use of the assessment results in order to help determine what to assess and how it should be assessed.

Table 1

Process for Developing a Prior Knowledge Assessment

Development Steps		Scope
Step 1	Determine what instruction will include tailored training	• What instruction will be tailored? o Entire training course? o Specific blocks of instruction?
Step 2	Determine which students will receive tailored training	• What type of tailored training is envisioned? o Additional assistance for students likely to struggle; and o Additional challenges for students likely to excel. • How will the results of the assessment be used to tailor training? o Identify students with little or no relevant prior knowledge; and o Identify students with much relevant prior knowledge. • What determines a low/high performer during training?
Step 3	Determine what prior knowledge areas to measure	• What knowledge areas are relevant to the training? • Will these knowledge areas affect the student's learning experience, particularly initial learning?

Development Steps		Scope
Step 4	Identify the specific content for each prior knowledge area	• What specific content will be assessed in each knowledge area? o Identify the specific content to assess within each knowledge area; and o Identify content that best defines desired student knowledge levels and understanding of selected knowledge areas.
Step 5	Develop the questions for the prior knowledge assessment	• What questions should be asked? o Use information from step 4 for content. • What type of assessment will be administered? o Hands-on, paper-based. • How many questions for each knowledge area? o Emphasis/time allotted per knowledge area during training. • What question formats will be used? o Multiple-choice, true-false, matching. • What cognitive level of understanding will be sampled by the questions in each knowledge area? o Knowledge, comprehension, application. • How difficult should be the questions in each knowledge area? o Easy, hard, complex. • How will the assessment be scored?

2.2 Step 1: What instruction will include tailored training?

Tailoring may be planned for an entire training course or for one or more blocks of instruction within a course. The first step in assessment development is to determine which training course or blocks of training will be tailored. Training that requires higher levels of proficiency, such as when students receive a certification, when their skills impact human or equipment safety, or when graduates will be required to operate high dollar systems, are often good candidates for tailoring. Less demanding training, such as when the intent is primarily to “familiarize” students with information, generally is not a good candidate for tailored training. Since the objective in these situations is simply familiarization, exact knowledge and skills are less important than in training requiring higher levels of proficiency.

With the assistance of the instructors, you should first examine your training to determine which courses or blocks of training are suited for tailored training and if the resources are available to implement the type of tailored training envisioned. Since the structure of training courses throughout the Army is diverse in nature, you will have to determine not only in which course, portion of a course, or block of training tailoring will be implemented, but also when the tailoring is likely to take place. Often, courses are sequential in nature and early learning in the course can greatly impact later learning. In these courses, building a firm foundation of core concepts early in the course is

essential to performing well in the remainder of the course. Tailoring may only be desired in the up-front portion of the course to build a sound foundation for later learning. Other courses are structured with various blocks of instruction that are not dependent on each other to achieve desired learning outcomes. In these courses, performance in one block may have little impact on performance in subsequent blocks. Tailoring in these courses may only be desired during certain blocks of instruction due to their difficulty, complexity, or resource requirements.

Advanced Leader Course (ALC) Training Practical Example

Step 1 - Determine what instruction will include tailored training

Training manager SFC Dan Cooper is preparing for a new group of ALC students. Instructors are considering using tailored training to assist with some of the instruction. Through past experience he knows that the block of instruction on Tactics and Operations tends to show a wider range of performance scores among students when compared to the other blocks. In that particular block of training he has noticed that some students tend to perform extremely well, while others have a much harder time. His past experience tells him this seems to be due to some students having certain prior knowledge that aids them in the training, while others do not.

SFC Cooper and the instructors decide to tailor training only for the Tactics and Operations block of instruction based on the assumption that differences in prior knowledge are consistently affecting student performance in this block. To assist in determining which students the tailoring should focus on, SFC Cooper decides to develop a prior knowledge assessment to identify student prior knowledge of material the instructors believe may be impacting student performance.

Note: The ALC training example above is included for further clarification and practical understanding. This practical example will be continued after the discussion for each of the development steps.

2.3 Step 2: Which students will receive tailored training?

The key to producing assessment results useful for predicting individual performance is to understand how the results will be used. In other words, you must first determine which students will be the focus of the envisioned tailored training in order to make sure the assessment identifies those individuals. For example, is the intent to find the most probable top performers in order to provide them with more challenging training, is it to find those who are more likely to struggle with the training in order to provide them additional assistance, or both? Regardless of how the predictions may be used, it is important to make that determination prior to developing an assessment.

For example, assume there are two instructors teaching the same block of training to two separate groups of students. You are planning to develop a prior knowledge assessment to assist the instructors in tailoring training. For each instructor you begin with Step 1 to determine which type of students the instructors want to focus their efforts on. The first instructor decides to provide additional challenges for the high achievers within the course to give them an opportunity to increase their knowledge and skills. The second instructor wants to know which students are most likely to struggle through the course without extra assistance. Although both prior knowledge assessments may contain questions within the same knowledge area, the focus and difficulty of the questions will likely differ. In the case of the assessment for the first instructor, a series of harder or complex questions may help identify those likely to excel. Those who can correctly answer the harder questions should also be able to answer lower level questions, therefore making those questions unnecessary. In the case of the second instructor, the desire is to find students with potential weaknesses on basic concepts or knowledge areas. For this assessment a set of low-level, basic questions may be all that is needed. More complex questions would not be necessary since students unable to properly answer low-level questions would most likely not be able to correctly answer more advanced ones.

ALC Training Practical Example

Step 2 - Determine which students will receive tailored training

Since this block of training is fundamental for leaders as they continue to advance in rank and position, the instructor believes that it is important for all students to have a good understanding of Tactics and Operations. With this in mind, he decides it is more important to assist those students who tend to have difficulty with the training than to challenge those for whom the training comes easier. Reflecting on his previous experiences and the performance of previous classes, he decides that students having at least a basic foundation of information relevant to the course in seem to have fewer problems during training. Therefore, the instructor asks SFC Cooper to develop a prior knowledge assessment to identify those students who are weaker in these relevant knowledge areas. His intent is to tailor training by providing additional assistance early in the course and outside of normal training hours to these particular students to bring them up to a level that will make classroom training easier and more meaningful.

2.4 Step 3: What Prior Knowledge Areas Should I Measure?

As can be seen in the above example, a critical step in prior knowledge assessment development is determining what knowledge should be measured. This guide has already stressed that *relevant* prior knowledge must be identified. Clearly, not all prior knowledge is relevant to the instruction. But how do you identify what prior knowledge is relevant?

A major factor to discovering what knowledge is relevant lies in a thorough understanding of the training content. You, along with the instructors, should examine the course content, required performance outcomes, and past students' performance trends, then reflect on what prior knowledge seems to best assist students in achieving the learning objectives of the training. Selection should be based on whether the prior knowledge allows students to grasp the learning content quicker and at a higher level than those without that knowledge. As discussed in Chapter 1, an assessment of prior knowledge is distinctly different from a pretest in that a pretest focuses on content taught during the course, and most likely tested in the course. The focus of a prior knowledge assessment is on core knowledge and skills not explicitly taught in the course, but still critical in that they enable quicker and/or higher learning in the course.

A second factor is to leverage the instructor's experience in teaching students enrolled in the course. Typically, experienced training personnel, over time, discover what prior knowledge students need to progress at or above the desired rate within the course and the consequences when this knowledge base is insufficient. Similarly, instructors are often aware of what additional prior knowledge gives students an advantage in the course.

Some training courses have defined prerequisites and their instructors expect a certain level of competency in those areas from students prior to attending the course. When knowledge-related prerequisites are specified, it is because the knowledge previously gained serves as a necessary basis for obtaining additional related knowledge (e.g., completion of a lower-level course). The same concepts apply in the vast number of courses that do not have readily defined knowledge related prerequisites. Students who possess some level of knowledge in relevant knowledge areas tend to excel in their learning and, alternatively, those unfamiliar with those knowledge areas often have more trouble learning the content being taught.

For example, consider new Soldiers attending a tracked vehicle mechanics course. They will be learning how to change broken components, service vehicles, and troubleshoot a variety of problems. Assume there are no prerequisites for this course. Students coming from a variety of backgrounds and experiences will soon arrive ready to be taught. From prior experience, the instructor knows that within this diverse group of students, some will possess knowledge that will assist them in the course and some will not. This instructor decides he wants to use a prior knowledge assessment to help identify those students that may have difficulty in the course in order to provide them with some tailored training to assist them. The instructor is in the best position to assist you in determining what knowledge areas are relevant to the training content and if prior knowledge in those areas will likely impact learning.

This instructor identifies two areas that should be examined in the prior knowledge assessment: common mechanic's tools used in general maintenance of vehicles and basic knowledge of electricity and wiring. Since a large portion of training builds on these two knowledge areas the instructor deems them as relevant to the training and

decides to have you design an assessment that includes questions in these areas. Since the intent is to tailor training to students who may require assistance during training, the questions are designed to discover which students do not have at least a low level, basic knowledge of each of these areas.

ALC Training Practical Example

Step 3 - Determine what prior knowledge areas to measure

As SFC Cooper prepares to develop the prior knowledge assessment, his instructor considers what specific prior knowledge he believes aids students in the Tactics and Operations block of instruction. The instructor knows that much of the training centers on planning tactical operations and subsequently producing operations orders to support them. As a former Operations NCO and instructor for the past two years, the instructor is well versed in all aspects of tactical operations and knows what knowledge is required to plan them along with their supporting documents. His experience both outside and inside the classroom leads him to conclude that there are three knowledge areas associated with the Tactics and Operations block of instruction in which he considers essential to success in training. These areas include basic knowledge associated with map reading (e.g., plotting grid coordinates, recognizing terrain features on the map, interpreting imagery and relating it to the map), graphic symbols (e.g., overlays, control measures), and creating operations orders (e.g., organization of information, content of each paragraph). His previous teaching experience has shown him that without a good basis of knowledge in these areas students tend to struggle and quickly fall behind other students in training.

2.5 Step 4: How Do I Identify the Specific Content for Each Knowledge Area?

Using the prior knowledge areas identified in step 3, you and the instructor must now determine what specific content within those areas will be used to generate questions in the assessment. Since knowledge areas can sometimes tend to be broad in nature, consideration should be given to determining what information within each knowledge area is potentially most relevant to the training of interest. Usually large knowledge areas consist of several smaller, more generalized knowledge areas in which some areas are potentially more relevant than others. In most cases it would be impractical to develop a comprehensive assessment covering all aspects of each knowledge area. The objective should be to select portions of the main knowledge area that are most relevant to the training and that would provide the best value for determining whether or not a student has prior knowledge within that area. You should consider asking yourself questions such as:

- “What is important within this knowledge area that makes it relevant to the training of interest?”
- “What is hard about the training as it relates to this knowledge area that makes it difficult for some students?”
- “What prior knowledge do higher performing students consistently have that help them perform well?”

In the maintenance example discussed in step 3, an instructor identified two knowledge areas including basic tools used in repairing vehicles and basic knowledge of electricity and wiring. Specific content within those two areas now needs to be determined. Identification and use of basic tools can consist of a vast amount of knowledge. However, it is not reasonable to expect students to arrive for training already completely familiar with all the tools they will use during training. Thus, the instructor focuses on basic tools commonly used in a number of repair and maintenance settings that higher performing students seem to be familiar with at the start of training. For example, the instructor determines that these students seem well versed in using different types of hammers, screwdrivers, wrenches (both standard and metric sizes), different types of calibration tools, and some types of basic power tools. In order to determine how familiar a student is with tools, either a sampling from each of these categories or from the most common or most used categories may be adequate. Since a majority of vehicle mechanical work is accomplished using fairly common hand tools, questions involving those items should indicate whether or not a student knows what they are and how to use them. Simple questions that determine if students know the difference between a flat tip and a Phillips (or cross tip) screwdriver, between standard and metric wrenches, or between a 1/4” and a 1/2” drive socket set may provide the instructor the desired information. Similarly, questions such as, “Which way would you turn a standard bolt to tighten it?”, or “From a group of tools, select the appropriate tool to remove the plate in the diagram below”, would provide additional information on tool use. These types of basic questions regarding tools would provide the instructor with an idea of students’ prior knowledge of tools. More difficult questions, such as on the use of a calibration wrench, may not be as useful if the intent is only to determine students’ basic familiarity with tools. A similar process could be used to determine the most relevant areas and content within the knowledge area of electricity and wiring to the training and develop questions to sample those areas.

ALC Training Practical Example

Step 4 - Identify the specific content for each knowledge area

SFC Cooper now turns his attention to the specific content to be included in the assessment. He considers what material within each of the knowledge areas of map reading, graphic symbols, and operations orders should be used to develop the questions for the assessment. In the knowledge area of map reading SFC Cooper and the instructor decide there are four basic areas of knowledge. Those include (1) map legend, (2) directions and azimuths, (3) scales, grids, and distances, and (4) terrain features.

Through experience the instructor has found that virtually all students are generally familiar with a legend and terrain features on maps or can learn that information very rapidly. Those less familiar with working with maps often have the most difficulty with directions and azimuths and with scales, grids, and distances. The instructor decides he only wants to include questions in those two areas on the assessment. In the knowledge area of graphic symbols, he decides he wants to include questions regarding commonly used unit symbols and graphic control measures. In the last knowledge area of operations orders, he knows that although his students will receive training on developing portions of an operations order, he has found that those familiar with basic aspects of operations orders tend to struggle less during the instruction. He has determined that in-depth knowledge of all sections of an operations order is not required prior to training. Therefore, he decides to include basic questions that focus on identifying the components of operations orders and describing what they are used for to help determine which students lack this basic understanding.

2.6 Step 5: How Do I Develop the Questions?

Typically the most time consuming portion of assessment development is the construction of the assessment questions. Developing good objective questions that properly assess the appropriate content is a challenging process that can take considerable time to complete. While true-false and matching questions can be relatively simple to construct, well thought out multiple-choice questions can be more difficult and time consuming. While you may choose to use any question format that meets your needs, the following paragraphs include several things you will want to keep in mind during question development.

Assessment Type

The most common types of assessments you are likely to use will be hands-on, paper-based, or a combination of the two. Hands-on assessments are administered to

students in a way that provides them the opportunity to perform a task or procedure, often with some associated equipment or material while an observer scores performance. Paper-based assessments consist of written questions students are expected to answer.

Hands-On Assessments

While hands-on assessments can be worthwhile, they also tend to be time consuming both in preparation and execution. You should take into account the time and resources available for set-up and administration of hands-on assessments to determine if they are feasible for your situation. Generally, each student would be observed individually which could require many observers and lots of equipment in order to complete the assessment in a reasonable amount of time. Hands-on assessments can be extremely diverse in makeup and administration depending on the subject matter covered and the methods used to determine the levels of prior knowledge being assessed. The uniqueness of hands-on assessment methods will require you to determine how levels of prior knowledge will be measured objectively. It may be worthwhile for you, with the assistance of the instructor, to first determine the questions you wish to be answered, such as those asked in paper-based assessments, and then determine how those questions can be transformed into a hands-on assessment. The assessment must be structured to yield an "objective", verifiable score, not a "subjective" opinion regarding the quality of a student's hands-on performance. Other considerations such as the number of knowledge areas to include and the length of the assessment will also need to be addressed.

You should keep in mind the following key points if considering using a hands-on prior knowledge assessment.

- Hands-on assessments are most often designed to be performance oriented requiring application of knowledge as well as factual knowledge. Application of knowledge concerns a higher level of cognitive understanding rather than simply knowing facts. Although hands-on assessments can be carefully designed to assess lower cognitive levels, assessing a student's knowledge of facts is often easiest using paper-based assessments. (Assessing student understanding using different cognitive levels will be discussed later in this chapter.)
- Hands-on assessments should be designed in a way that allows for an objective assessment using a continuous numerical measurement, such as a percentage of correct answers, for scoring. A single dichotomous score, such a "Go/No-Go" or "Pass/Fail", will not give the level of detail needed for a prior knowledge assessment. While dichotomous scores are applicable for subsequent measurements of performance, which will be discussed later, they should be avoided if possible when designing prior knowledge assessments. In order to objectively score a hands-on assessment using continuous numerical measurements, some type of detailed checklist would have to be developed. The checklist would be used to score individual

student performance which in turn could be converted to an assessment score.
- The length of a hands-on assessment is directly related to how long it takes for a student to perform the tasks as well as how many students can be assessed simultaneously. When using hands-on assessments, you may find that a limitation in time available for administration results in a limitation of the amount of knowledge that can be assessed.
- Hands-on assessments most often require additional resources beyond those needed for paper-based assessments. These additional resources may include:
  - Equipment – Hands-on assessments will require some type of equipment and/or other materials which must be collected for use.
  - Set up time – A hands-on assessment requires additional time to set up equipment.
  - Administration time – Additional administration time is often required as most often all students cannot be assessed at the same time. Most often one observer per student is required during assessment.
  - Observers – To reduce administration time multiple observers are often required in order for multiple students to be observed at the same time.

Although hands-on assessments can be applicable for determining a student's level of prior knowledge, paper-based assessments tend to be an easier and more efficient solution. While the remainder of this guide discusses paper-based assessments, much of the information and concepts may also be applied to hands-on assessments.

Paper-based Assessments

Paper-based assessments tend to require fewer resources, be less time consuming to prepare, and are easier to administer than hands-on assessments. Much like written tests and knowledge checks during training, written assessments usually consist of questions developed in different formats for students to answer. They also tend to be simple to score and contain clearly correct responses, rather than depending on more subjective assessments of hands-on task performance. These factors make comparison for validation and predictions easier. The challenge with paper-based assessments is in the development of questions that provide a good sample of a student's level of prior knowledge in the areas being assessed.

Question Format – Paper-based

The time needed to complete a paper-based assessment depends largely on the number of questions, the question formats, and the complexity of the questions. Logically, more questions and more complex questions take longer for a student to answer than fewer and simpler questions. In determining how many questions to ask for any particular knowledge area, you should keep in mind the total administration time required to allow students a reasonable opportunity to answer all of the questions.

Table 2 provides some general guidelines to assist you in determining the time needed to complete different types of questions most commonly used in Army training settings.

Table 2
Question Formats and Estimated Time to Complete

Question Format	Time per Question	Difficulty
True-false	20-30 seconds	Easy
Multiple-choice (factual)	40-60 seconds	Moderate
Multiple-choice (complex)	70-90 seconds	Hard
Matching (5 stems/6 choices)	2-4 minutes	Variable

Strictly objective questions, such as true-false, multiple-choice, or matching tend to be the most useful for Army training. These questions are relatively quick and easy to score with no need for interpreting answers. Some question formats, such as essay questions, take longer to answer, tend to be harder to grade, and increasingly depend upon some degree of subjective reasoning on the part of the grader to score. While there is nothing inherently wrong with using these question formats, the time required for answering and grading them and the need to standardize subjective judgments across different graders often makes using them less practical. However, this guide assumes that you will most likely construct questions using the question formats listed in Table 2 due to their familiarity, objectivity, and ease of scoring.

Question Difficulty – Paper-based

You must also consider the difficulty of the questions. Question difficulty in this guide is described as easy, moderate, hard, and variable. You may create a hard knowledge-based question in one instance, and an easy application-based question in another. There is variability in difficulty with each question format depending on the content and how the question is worded. However, regardless of question format, in general, easier questions require less time to answer while as the questions increase in difficulty, more time is needed. The example questions below on graphic control measures illustrate different degrees of difficulty.

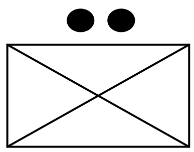
Easy true-false question:

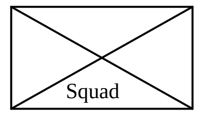
In response to the following statement circle T for true or F for false.
<u>T</u> F "The basic symbol for a friendly ground unit is a rectangle."

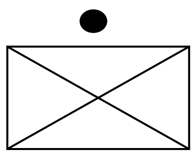
Moderate (easy) multiple choice question:

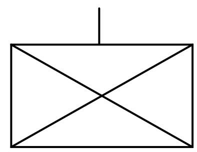
Circle the correct letter to answer the following question:

"Which of the following is the correct symbol for an infantry squad?"

A. 

B. 

C. 

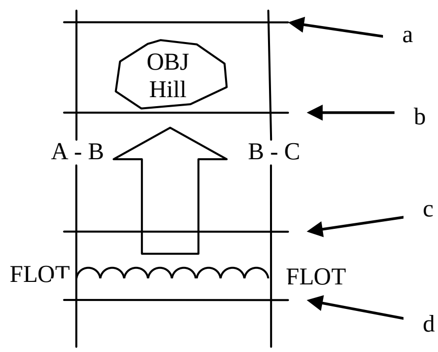
D. 

Moderate (difficult) multiple choice question:

Circle the correct letter to answer the following question:

"In the graphic below, at which location would you place a FCL?"

A. At location "a"
B. At location "b"
C. At location "c"
D. At location "d"

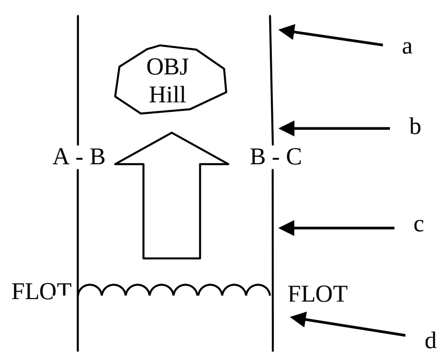


Hard (complex) multiple choice question:

Circle the correct letter to answer the following question:

"In the graphic below, select the proper symbol and placement for a FCL."

A. "Solid line" at location "a"
B. "Dashed line" at location "a"
C. "Solid line" at location "b"
D. "Dashed line" at location "b"
E. "Solid line" at location "c"
F. "Dashed line" at location "c"
G. "Solid line" at location "d"
H. "Dashed line" at location "d"



This last example is of a difficult matching question that requires the student to know multiple facts about graphic control measures. To answer all portions of this question correctly, one must know what the acronyms stand for as well as what each is used for. Also, note that there are more “functions” than “control measures.” This helps reduce the impact of simple guesswork through the elimination of alternatives as known matches are selected.

Difficult matching question:

“Match the control measure in the first column with its function in the second column by placing a letter in the blank next to a number.”

___ 1. FCL	A. Line to coordinate departure of attack elements
___ 2. LOA	B. Designed to impede enemy movement
___ 3. FSCL	C. Used to lift or shift fires
___ 4. LD	D. Used for coordination of air, land, and sea fires
___ 5. FLOT	E. Limits of ground combat units except screening/covering units
___ 6. FEBA	F. Used for control and coordination of military operations
___ 7. LC	G. Prohibits fires or effects from fires across the line
___ 8. PL	H. Forward positions of friendly forces
___ 9. FPF	I. Boundary of area in which gunfire can be delivered
___ 10. RFL	J. Where two opposing forces are engaged
	K. Terrain feature beyond which attacking units may not advance

Cognitive level – Paper-based

You may also need to determine the cognitive level of each question prior to developing it. The cognitive level of a question is not the same as its difficulty. The cognitive level of a question involves the first three levels of cognitive understanding as commonly used in the field of education. These levels include “factual” knowledge within some particular area, “comprehension” of that knowledge, and “application” of that knowledge. Basic knowledge within an area involves remembering facts, terms, concepts, definitions, and principles that pertain to the subject or material within a particular knowledge area. Comprehension involves a further understanding of those facts to include what they mean and how they relate to other facts. Application involves an understanding of how to take those facts and make them useful by applying them to various situations to solve problems. Each of the four levels of difficulty may be applied in each of the three levels of understanding.

You may decide to formulate questions using some or all of these levels depending on what you deem as important prior knowledge. Further understanding of student knowledge may be gained with questions that involve comprehension and application rather than simple fact-based questions. Comprehension and application of facts automatically requires knowledge of the fact itself. You will have to determine what levels are important for your purposes. As an example, a simple fact based question may be, “From the pictures, identify the screwdriver.” A comprehension question involving the same material may be, “true or false: Screwdrivers are used to tighten bolts.” An application question may be, “From the list of tools to the right, choose the

proper tool to remove the cover on the piece of equipment shown." All three questions involve the same material but at different cognitive levels. You must decide what cognitive level(s) you will use to design the questions in each knowledge area.

To help with construction of knowledge-based, comprehension-based, and application-based questions, Table 3 provides suggested words that may be used in various forms to help develop questions that generally relate to the cognitive level of the question desired. While the questions do not necessarily need to include any of these words, they do provide a basis of thought during question development.

Table 3
Question Cognitive Level [1]

Asking a:	Involves:	May include words:
Knowledge based question	Remembering facts, terms, concepts, definitions, principles	Define, list, state, identify, label, name, who?, when?, where?, what?
Comprehension based question	Understanding, explaining, or interpreting the meaning of material	Explain, predict, interpret, infer, summarize, convert, translate, give example, account for, paraphrase
Application based question	Using a concept or principle in various situations to solve problems	Apply, solve, show, make use of, modify, demonstrate, compute

As an example, consider the following three simple true-false questions.

<u>T</u> F "Lug nuts are found near the wheel of a vehicle."
<u>T</u> F "To remove a wheel you must first remove the lug nuts."
<u>T</u> F "Lug nuts are loosened and removed with a counter clockwise action using the lug wrench."

All three of these true-false questions are asking about similar content. However, the first question is an example of one that requires the student to recall a specific fact. In the second question the student must comprehend the function of lug nuts in order to answer the question correctly. In the third question, the student must not only understand the function of lug nuts, but apply that knowledge in conjunction with knowledge and understanding of tightening and loosening lug nuts and whether the tools listed are necessary for that operation.

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[1] Adapted from the Indiana University resource document "How To Write Better Tests", online at "http://www.indiana.edu/~best/pdf_docs/better_tests.pdf"

Formulating Questions

As discussed earlier in this guide, you need to carefully consider the content, format, difficulty, and cognitive level of each question in your assessment. A good approach is to determine what basic content will be in a question and then decide what format would best suit that content and your desired difficulty and cognitive level. For example, matching questions work well with knowledge based questions. You should keep in mind your purpose behind the assessment while developing your questions. Writing tricky or intentionally misleading or trivial questions serves little purpose in determining whether or not a student already knows or comprehends the material you are sampling. Trivial information that does not adequately assess a student's level of knowledge, comprehension, or understanding of key ideas and concepts will not assist you in determining a student's level of relevant prior knowledge.

The remainder of this section provides some considerations and tips for developing questions in different formats[2]. Question examples are provided to illustrate how to develop each type of question. A variety of questions used in different actual prior knowledge assessments is provided in Appendix D as additional examples.

> *Note: The following questions are examples that demonstrate different question formats and to show how questions may be developed. Exact question content and wording can further increase the difficulty of questions.*

True-false Questions

True-false questions are generally easy to construct and are often used for student recollection of factual material and other knowledge-based information. However, they can also be used for higher level cognitive reasoning requiring comprehension and application of knowledge. As shown in Table 2, true-false questions take relatively little time to answer. A potential drawback to the use of true-false questions is the fact that when students do not know the correct answer, they have a 50 / 50 chance of guessing right. When writing a true-false question, you must ensure the answer is unmistakably either true or false.

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[2] These tips were adapted from the Indiana University resource document "How To Write Better Tests", online at "http://www.indiana.edu/~best/pdf_docs/better_tests.pdf" and the University of Waterloo resource document "Exam questions: types, characteristics, and suggestions", online at "https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/developing-assignments/exams/questions-types-characteristics-suggestions".

Consider the following guidelines during construction of true-false questions.

- **Ask questions involving significant or major content and avoid trivial information.**

Poor:
In response to the following statement circle T for true or F for false.
T F "The height of the thread on a course thread bolt is higher than the thread on a fine thread bolt of the same size."
Better:
In response to the following statement circle T for true or F for false.
T F "To tighten most common bolts you would turn them clockwise."

Comment: Specific knowledge of thread height on bolts can be considered trivial and non essential prior knowledge while knowing how to tighten and loosen bolts is a common mechanical operation that is more relevant to vehicle maintenance tasks.

- **Make sure the question is clearly true or clearly false.**

Poor:
In response to the following statement circle T for true or F for false.
T F "Antifreeze is used to fill up a radiator."
Better:
In response to the following statement circle T for true or F for false.
T F "A mixture of antifreeze and water is used to fill up a radiator."

Comment: Antifreeze is used in radiators but not to "fill it up." Water is also used to dilute it. Careful construction of the question will avoid this type of confusion.

- **Avoid trick questions.**

Poor:
In response to the following statement circle T for true or F for false.
T F "A tire is often removed using a lug wrench."
Better:
In response to the following statement circle T for true or F for false.
T F "A wheel is often removed using a lug wrench."

Comment: Wheels are commonly removed from vehicles by using a lug wrench to remove lug nuts. Tires on the other hand are mounted to the wheels and are removed using various other tools and machines. Trick questions may assess the attentiveness of a student but not necessarily their level of prior knowledge.

- **Include only one major point per question.**

Poor:
In response to the following statement circle T for true or F for false.
T F "A 1/2 inch six point socket with a 3/8 inch drive will fit a 1/2 inch nut as long as the nut does not screw down on the bolt further than the socket can reach in which case a 1/2 inch twelve point, deep well socket or a 1/2 inch open end wrench may be used."
Better:
In response to the following statement circle T for true or F for false.
T F "A 1/2 inch socket with a 3/8 inch drive will fit a 3/8 inch bolt."

Comment: More than one main point, such as socket points, socket drive, and deep well sockets, causes confusion and can become an exercise in deciphering the question rather than assessing prior knowledge. Additionally, longer worded statements may often be answered "False" as students answering may believe that some portion has to be incorrect.

- **Avoid negatively stated questions.**

Poor:
In response to the following statement circle T for true or F for false.
T F "You would not want to turn a bolt clockwise to the right to loosen it."
Better:
In response to the following statement circle T for true or F for false.
T F "To loosen a bolt you would turn it counterclockwise, to the left."

Comment: Negatively stated questions can cause a student to answer incorrectly even when the correct answer is known.

- **Avoid absolute encompassing words such as "always", "all", or "never".**

Poor:
In response to the following statement circle T for true or F for false.
T F "You should always turn bolts to the right to tighten them."
Better:
In response to the following statement circle T for true or F for false.
T F "You should generally turn bolts to the right to tighten them."

Comment: Questions including all encompassing words are often false since relatively few instances are so absolute. As a general rule, most bolts are turned to the right to tighten them. However there are some reverse threaded bolts for specific purposes that turn to the left to tighten them rendering the answer false if the term "always" is used.

- **Avoid long, complex questions.**

Poor:
In response to the following statement circle T for true or F for false.
T F "If a bolt is surrounded by other material and difficult to reach with a socket wrench, and you have tried to reach it with an open end wrench but failed, and you were unable to remove the surrounding equipment to better reach the bolt, a socket wrench extension may be used as long as the bolt is in a position to where the extension can reach it."
Better:
In response to the following statement circle T for true or F for false.
T F "If a bolt is surrounded by other material and difficult to reach with a socket wrench, a socket wrench extension may be of use."

Comment: Unnecessary, wordy information that does not add relevant content, meaning, or clarification often distracts from the main content. Including the failed attempts at reaching the bolt adds little to the information necessary for determining whether or not the student knows the purpose of a socket wrench extension.

Multiple-Choice Questions

Multiple-choice questions are one of the most common formats used in assessments due to their objectivity and versatility. Multiple-choice questions consist of two parts including a stem and a list of possible solutions. The stem of the question presents the first part of a problem which must be completed or answered from the list of possible alternatives. Stems may be in the form of a question or in the form of an incomplete sentence with both requiring an answer from the accompanying list of solutions. In comparison to true-false questions, there is a significant reduction in the ability of a student to correctly guess the correct answer of a multiple-choice question. Unlike true-false questions where half the time a student is likely to guess correctly, multiple choice questions provide greater opportunities to reduce the impact of guessing on student scores. Multiple-choice questions maintain their objectivity by providing only one correct response for a properly worded question. In addition, they provide a greater ability to assess knowledge and understanding across all three cognitive levels, to determine a student's knowledge of facts and information, to measure the comprehension of those facts, or to measure subsequent application of that knowledge in problem solving. While not necessarily the case, multiple choice questions that tend to be more complex also tend to assess more than factual knowledge. As shown in Table 2, complex multiple-choice questions also take longer to answer than simpler questions. While multiple-choice questions can be difficult and time consuming to construct, they are relatively simple and easy to score. During development of multiple-choice questions you should review the considerations given for true-false questions as well as the following general guidelines.

- **Though it is easier to write low-level knowledge questions, you should also include questions that assess higher levels of cognitive understanding.**

Poor:
Circle the correct letter to answer the following question:
"Which of the following fluids goes in a vehicle's cooling system?"

A. Transmission fluid
B. Antifreeze
C. Washer fluid
D. Brake fluid

Better:
Circle the correct letter to answer the following question:
"Which of the following fluids is commonly required to repair a vehicle whose engine is running hot?"

A. Transmission fluid
B. Antifreeze
C. Washer fluid
D. Brake fluid

Comment: More information can be determined about a student's level of understanding when questions require further thought rather than simple recall. The second question involves both diagnosis and solution as opposed to simple fact.

- **Make sure the stem fully states the problem or question.**

Poor:
Circle the correct letter to answer the following question:
"Which of the tools is best to use on a wheel?"

A. Lug wrench
B. Screwdriver
C. Hammer
D. Box end wrench

Better:
Circle the correct letter to answer the following question:
"Which of the following tools is best suited for removing the nuts on a wheel?"

A. Lug wrench
B. Screwdriver
C. Hammer
D. Box end wrench

Comment: Leaving room for interpretation can lead to confusion. Without clearly stating what is required, students may be left wondering things like "Best in what sense?"

- **Place words in the stem that would otherwise be repeated in the solution options.**

Poor:
Circle the correct letter to answer the following question:
“A socket wrench is:”

A. used to tighten screws
B. used to remove bolts
C. used to adjust a carburetor
D. used to install wiper blades

Better:
Circle the correct letter to answer the following question:
“A socket wrench is used to:”

A. tighten screws
B. remove bolts
C. adjust a carburetor
D. install wiper blades

Comment: Repeated words in the solution distract from the more important information.

- **Make the stem as concise as possible without losing meaning.**

Poor:
Circle the correct letter to answer the following question:
“As part of servicing a vehicle for routine maintenance, where would you find the engine oil drain plug to drain the oil in order for you to replace it with new oil?”

A. Near the top of the engine
B. On the bottom of the transmission
C. On the bottom of the oil pan
D. Next to the oil cap

Better:
Circle the correct letter to answer the following question:
“Where is the oil drain plug located?”

A. Near the top of the engine
B. On the bottom of the transmission
C. On the bottom of the oil pan
D. Next to the oil cap

Comment: Unnecessary or excess words in the stem that do not add relevant content, meaning, or clarification often distract from the more important information. The fact that the engine is being serviced or that new oil will be put into the engine has no relevancy to the student knowing where the oil drain plug is located.

- **Ensure there is only one correct response in the solution list.**

Poor:
Circle the correct letter to answer the following question:
“Which of the following fluids is commonly required to repair a vehicle engine that is running hot?”

A. Transmission fluid
<u>B</u>. Antifreeze
<u>C</u>. Water
D. Brake fluid

Better:
Circle the correct letter to answer the following question:
“Which of the following fluids is commonly required to repair a vehicle engine that is running hot?”

A. Transmission fluid
<u>B</u>. Antifreeze
C. Washer fluid
D. Brake fluid

Comment: Having more than one correct response per question can be confusing even if the student knows the answer. “Water” and “Antifreeze” are both coolants for the engine.

- **Provide between three and five possible solutions.**

Poor:
Circle the correct letter to answer the following question:
“A 1/2 inch drive socket wrench means:”

A. that wrench can only be used on 1/2 inch bolts and nuts
<u>B</u>. the connector portion of the wrench to the sockets is 1/2 inch

Better:
Circle the correct letter to answer the following question:
“A 1/2 inch drive socket wrench means the:”

A. wrench can only be used on 1/2 inch bolts and nuts
<u>B</u>. connector portion of the wrench to the sockets is 1/2 inch
C. wrench can only be used on nuts and bolts of 1/2 inch and below
D. sockets in the set are in increments of 1/2 inch

Comment: Too few solutions increase the chance that students can guess the correct answer.

- **Solution options should be of similar nature with only one correct response.**

Poor:
Circle the correct letter to answer the following question:
“Spark plugs are:”

A. usually blue in color
B. made completely out of metal
C. used to ignite gas inside a gas engine
D. not used in diesel engines

Better:
Circle the correct letter to answer the following question:
“Spark plugs are used to ignite:”

A. diesel inside diesel engines only
B. gas inside diesel and gas engines
C. gas inside a gas engine only
D. gas inside a gas engine and diesel inside a diesel engine

Comment: The intent of this question is to assess whether or not students know that spark plugs are only found in gas engines and are used to ignite the gas. Response options that are similar in nature, such as in the second question, require the student to think more deeply in order to decipher which is the correct answer.

- **Avoid using “all of the above” or “none of the above” as these options make guessing easier.**

Poor:
Circle the correct letter to answer the following question:
“In the list below, which is a type of wrench?”

A. Socket
B. Box end
C. Crescent
D. Lug
E. All the above

Better:
Circle the correct letter to answer the following question:
“In the list below, which is a type of wrench?”

A. Phillips
B. Vice grip
C. Crescent
D. Needle nose
E. Ball peen

Comment: With response options such as “All the above”, students who know that “crescent” and “socket” are both a type of wrench do not have to know that “box end” and “lug” are also in order to guess the correct “All the above” response.

- **Ensure questions are stated so there is only one interpretation of the meaning of the stem.**

Poor:
Circle the correct letter to answer the following question:
"To check the battery on a vehicle you would:"

A. Attempt to crank the vehicle
B. Check it with a battery analyzer
C. Attempt to make the terminal spark when connecting battery cables
D. Look at the battery charging indicator inside the vehicle

Better:
Circle the correct letter to answer the following question:
"To check the voltage and cold cranking amps of a vehicle battery you would:"

A. Attempt to crank the vehicle
B. Check it with a battery analyzer
C. Attempt to make the terminal spark when connecting battery cables
D. Look at the battery charging indicator inside the vehicle

Comment: Checking the battery could mean a variety of things such as: check to see if it is there, check to see if it is cracked, check to see if it will crank the vehicle, check to see what the current cold cranking amps are, or check to see if it is hooked up properly.

- **Consider the use of diagrams, pictures, charts, tables and figures for application of principles and concepts.**

Example 1:
Poor:
Circle the correct letter to answer the following question:
"What does a ball peen hammer look like?"

A. Flat on one end and round on the other
B. Flat on both ends
C. Flat on one end with a claw on the other
D. Flat on one end and pointed on the other

Better:
Circle the correct letter to answer the following question:
"Which of the items below is a ball peen hammer?"

A. 

B. 

C. 

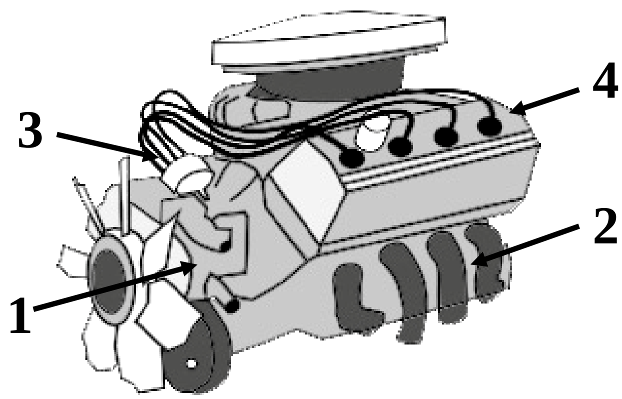
D. 

Example 2:
Poor:
Circle the correct letter to answer the following question:
"Where are the spark plugs generally located on a gas engine vehicle?"

A. Near the cooling fan
B. Near exhaust manifold
C. Near the distributer
D. Near the valve covers

Better:
Circle the correct letter to answer the following question:
"Where are the spark plugs located in the engine diagram?"

A. 1
B. 2
C. 3
D. 4



Matching Questions

Matching questions consist of two lists in which individual items in the first list carry a specific association with an item from the second list. Items within both lists may be in a variety of forms to include sentences, numbers, single words, descriptions, diagrams, and labels. Matching questions are relatively easy to create for factual based knowledge information but much more challenging for comprehension and application questions. The format for matching questions is only constrained by your imagination as you develop them. However, the considerations given for true-false and multiple-choice questions generally apply as well as the following guidelines.

- **Always include more responses than questions.**

Poor:

"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Hydraulic fluid for the master cylinder
___ 4. Antifreeze	D. Lubricant for the engine
___ 5. Grease	E. Lubricant for the gears

Better:

"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: Students who know all but one answer will correctly answer the last item if only one choice remains.

- **Include directions that clearly state the basis for the association between the items in the two lists.**

Poor:

"Pick the correct answers."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Better:

"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: Without clearly stating what is required, students are left to interpret what they believe the question is asking them to do. The term "correct" may mean different things to different students.

- **Items in each list should be of similar nature.**

Poor:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Tightens and loosens nuts and bolts
___ 2. Lug wrench	B. Cleans the windshield
___ 3. Wiper blades	C. Test the cold cranking amps
___ 4. Battery analyzer	D. Used to remove wheels
___ 5. Wrench	E. Sets gaps in spark plugs
	F. Lubricant for the engine

Better:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: Listing items with similar characteristics provides a better assessment of whether or not the student understands the content by having them decide between multiple answers. Items with different characteristics are often easily answered due to elimination of answers that make no sense. It makes no sense that wiper blades would be used for anything in the list other than cleaning the windshield.

- **Use different identification systems for the two lists (i.e. numbers/letters).**

Poor:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ A. Oil	A. Coolant for the engine
___ B. Brake fluid	B. Lubricant for the ball joints
___ C. Transmission fluid	C. Lubricant for the carburetor
___ D. Antifreeze	D. Hydraulic fluid for the master cylinder
___ E. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Better:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: Using letters for both lists could be confusing to the student. Using numbers and letters helps clearly determine which two items match.

- **Make sure all responses are believable.**

Poor:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Fluid for waxing a vehicle
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Better:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: "Fluid for waxing a vehicle" does not fit into the same common category as the fluids within vehicle components, has nothing to do with mechanical operations, and will generally be ruled out as a believable answer.

- **Make sure there is only one correct response per question.**

Poor:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Water	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Fluid for the radiator
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Better:
"Match the item in the first column with its function in the second column by placing a letter in the blank next to a number."

___ 1. Oil	A. Coolant for the engine
___ 2. Brake fluid	B. Lubricant for the ball joints
___ 3. Transmission fluid	C. Lubricant for the carburetor
___ 4. Antifreeze	D. Hydraulic fluid for the master cylinder
___ 5. Grease	E. Lubricant for the engine
	F. Lubricant for the gears

Comment: Having more than one correct response per question can be confusing even if the student knows the answer. "Water" and "Antifreeze" are both coolants for the engine.

Assessment Length – Paper-based

The length of a paper-based assessment depends on several factors. Some of these include the time available for administration, the number of knowledge areas covered, the number of questions needed to adequately sample each knowledge area, and the question format. To maximize the probability that the assessment will provide the best estimate of relevant prior knowledge, first determine the question content and the number of questions in each knowledge area likely to meet your needs. Then estimate how long it would take for students to answer those questions. If only a fixed, limited amount of time is allotted for the administration of an assessment, then the maximum number of questions can be determined by how many questions in the desired question formats, students will likely be able to answer during that time period. If the estimated time to answer questions is longer than what is available, consider modifying some of the question formats to adjust the time requirement, or do a quick pilot test to check on the time to complete the assessment.

When determining the number of questions to be asked in each knowledge area you should consider: the amount of content within each area and the potential impact each area has on student performance during the course compared to other knowledge areas. Those areas with more content and/or more potential impact would likely require more questions than those areas with less content and/or less potential effect. As a general rule, you may start with a basis of 20 to 30 questions per area and adjust up or down for each knowledge area as needed.

Although an assessment of prior knowledge is fundamentally different than a test for knowledge acquired during training, the principles of designing either a test or an assessment remain basically the same. The number of questions needed to determine some level of understanding is similar in both cases. Research has shown that for any particular knowledge area, some minimum number of questions is needed to adequately sample the student's knowledge. There is also a point at which asking more questions becomes futile in that it will not significantly increase the accuracy of the level of knowledge measured. On average, the number of questions should fall somewhere between 20 and 30 for any given knowledge area. In other words, if a 25-question assessment containing properly designed questions revealed a score of 75% for a given student, then a 100-question test on the same subject matter, at the same level of assessment, would not significantly alter those results as the student would likely score near 75% on that test as well. However, asking 5 questions on the same subject may not be enough to properly assess the student's scope and depth of knowledge. This generally holds true for any particular knowledge area. Assessments that include more than one knowledge area will need to include an adequate number of questions for each area.

Scoring of Assessments

Consideration should also be given as to how students' responses will be scored. Most scoring methods often involve assigning one point to each question and giving a score based on a raw measure, such as a score of 26 out of 30 questions, or as a percentage such as 87%, derived by dividing 26 by 30. Individual scores can be compared to other student scores to give an indication of where that student falls within the group. If more than one knowledge area is assessed, consideration should be given as to if and how each area will be scored independently. Scoring all areas as a single group may or may not provide you the information you need. You should ask yourself, "Will an overall combined score of all areas provide the information needed to tailor the training envisioned or does each knowledge area need to be scored separately to appropriately tailor training in each area?"

ALC Training Practical Example

Step 5 - Develop the questions for the prior knowledge assessment

Having decided on what content will be covered in each knowledge area, SFC Cooper considers the number and type of questions needed for each area. He decides to use a variety of question types in his assessment that include true-false, multiple-choice, and matching in each area. Since his objective is to determine which students do not have a basic understanding of the selected knowledge areas, he decides to use only easy or moderately difficult questions. To help determine students' level of understanding, he also decides to ask a combination of factual, comprehension, and application questions in each knowledge area.

Since the instructor views all three knowledge areas essential to helping him tailor training appropriately, SFC Cooper decides that due to the amount of content in graphic symbols and operations orders that he will include more questions in each of these areas. He finally decides to ask 4 true-false and multiple-choice questions on map reading and 8 true-false and multiple-choice questions each on graphic symbols and operations orders for a total of 20 questions. He also plans on developing one matching question, consisting of 5 items, for each knowledge area to produce an assessment of 35 possible correct answers. He decides that scoring one point for each correct answer will provide the best way to compare individual student results. Since the tailored training plans will not change based on the specific results from each knowledge area, he decides to use a combined score across all knowledge areas. Based on the number and types of items in his assessment, SFC Cooper plans to allow 30 minutes for students to complete the assessment (see Table 2).

Chapter 3. Validating Prior Knowledge Assessments

3.1 What is Validation?

In this guide, validation means ensuring your prior knowledge assessment detects the students you designed it to identify. In simple terms, validation basically means confirming the assessment meets your needs. There are several of types of validity. For the purposes of this guide, validation of prior knowledge assessments will center on the use of predictive validity. Predictive validity is the extent to which scores on an assessment predict scores on subsequent performance.

As such, your assessment is only as good as its use in predicting performance outcome to an acceptable degree. The closer the assessment comes to predicting actual performance, or being related to actual performance, the better tool it is. In mathematical terms, the strength of this relationship is reflected in the correlation between the two measures. Validation is the process of checking to ensure that an acceptable relationship exists between an assessment and actual performance. Validation should be completed prior to using an assessment to predict subsequent training outcomes. Once an assessment is validated, it may be used for multiple iterations of training unless revalidation, as explained in Chapter 4, *Using and Revising Prior Knowledge Assessments,* is necessary.

A key and necessary assumption is made in regards to the prior knowledge assessment you have designed. It is assumed that the assessment scores for a given group of students during the validation phase are representative of scores that will be generated by students taking the same prior knowledge assessment in subsequent classes. This assumption is necessary in order to make informed decisions about tailored training using the information gained from assessment results.

When validating your assessment, you will compare a measurement before existing training with a measurement after existing training. These two measurements are considered to be related if their outcomes are associated in a consistent manner. In other words, if the assessment measurement systematically correspond to actual performance measurements, meaning a student's score on one indicates a score on the other, then they are considered to be related. As an example, a glass jar containing some volume of sand weighs a certain amount. Adding more sand to the jar increases the weight and the volume. Adding even more sand correspondingly increases the weight and volume once again. Therefore, the first measurement, the volume of sand in the glass, is related to the second measurement, the weight of the sand in the jar. This type of relationship is directly proportional and very consistent since the volume of sand directly relates to the weight.

However, measurements can often be described as being related even though their relationship is less consistent than increasing volume and weight. For example, the more horsepower a car has, the faster it can generally go. The relationship is not always consistent however. Other factors such as weight and aerodynamic design can also influence speed. But there still remains a relationship between horsepower and speed which allows for some general conclusions about speed given horsepower. A poor relationship would exist where one measure has little or no consistent relationship with the second measure. An example of a poor relationship would be the color of a car and how fast it can go, since color has virtually no effect on car speed.

The usefulness of a prior knowledge assessment can be quantified by the strength of the relationship between the scores on the assessment and scores on the criterion performance measure. The strength of this relationship can be stated in terms of a correlation coefficient (described later in steps 3 and 4 of the validation procedure, paragraph 3.4 of this guide). If predictions based on a prior knowledge assessment fail to reflect how students actually perform after training, the assessment is of little use. Keep in mind, assessments will not be able to offer predictions with 100% accuracy. Validation comes from obtaining a correlation coefficient with a value high enough to support use of the assessment. To assist in validation, this chapter includes instructions for developing an Excel spreadsheet to compute values of a correlation coefficient.

3.2 What are the Input Values Used for Validation?

There are three sets of input required for validation. They are the scores on the assessment, the scores on the criterion, and student identification information. The assessment scores are obtained when the prior knowledge assessment is administered. The criterion scores are obtained at the end of some specified training which is not yet tailored, and therefore represent student performance typical of non-tailored training. ***For purposes of validation, assessment scores are not used to tailor scheduled training in any way, but rather to support the assessment's subsequent use.***

Drawing any conclusions from assessment results prior to validation can lead to incorrect conclusions regarding which students should be identified for tailored training. Validation is necessary in order to determine if there is a relationship between selected prior knowledge and actual student performance. Altering training based on pre-validation assessment results at this point would alter student subsequent performance and leave no way of determining whether the results predicted by the prior knowledge assessment were meaningful or accurate.

3.3 How Do I Establish My Performance Criterion for Validation?

The criterion you use for validation is a performance measurement based on the objectives of the course or block of training in which tailored training is planned. The key to establishing the criterion is to first ensure it is based on course or training block

objectives. Likely this measurement exists in some form already within the course or can be derived from available test scores, evaluation scores, or course performance ratings. However, criterion measurements should be obtained from measurements potentially impacted by the presence of relevant prior knowledge, or lack thereof. Using criterion measurements based on ratings not associated with relevant prior knowledge can lead to misguided decisions on which students may benefit from tailoring. While course performance measurements may already exist, they may also include ratings based on performance not impacted by the assessed prior knowledge. Criterion measurements should not include measurements not relevant or potentially relevant to the presence of prior knowledge.

Criterion measurements may be obtained at the completion of all training or at some point earlier. A determination of when to collect criterion measurements will have to be made depending on what is being measured and how the performance it measures relates to other training within the course. Learning in courses that are sequential in nature tends to build upon concepts and information as the course progresses. Since early learning in the course impacts later learning, criterion measurements may best be obtained after initial training of the identified knowledge area(s). You should keep in mind that collecting criterion measurements early in training often offers data better representative of the effects of prior knowledge, as these effects tend to fade as training progresses.

In the sequential progressive training for the course shown in Figure 1 below, Test 1 measures performance on training provided up to that point. Performance on Tests 2, 3, and 4 build upon earlier learning. In this case it may be best to establish the criterion at point A based on the results of Test 1 rather than at point B following the completion of Test 4. In that way performance results early in the course can be compared to assessment results to determine the impact of relevant prior knowledge on early learning.

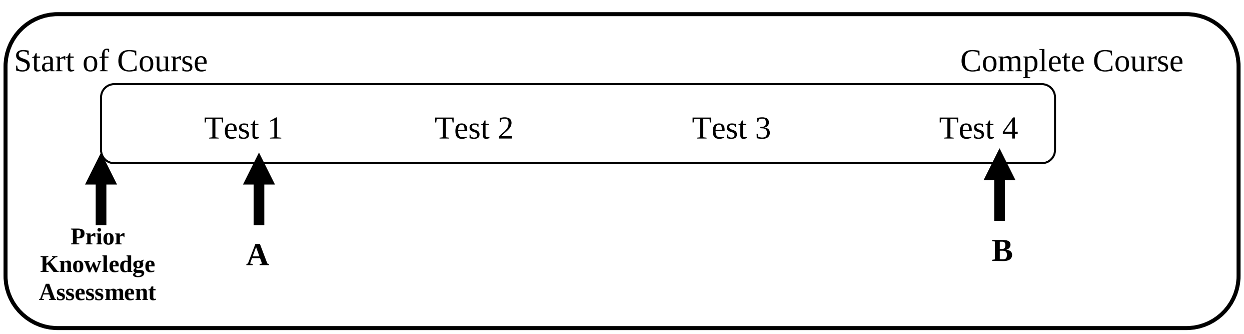


***Figure 1*.** Course X – sequential progressive training.

Other courses are structured with various blocks of instruction that are not dependent on learning between blocks. In these courses, performance in one block may have little impact on performance in subsequent blocks. Tailoring in these courses may be limited to certain blocks of instruction.

In the course shown in Figure 2 below, training is broken into four separate training blocks. Each block is independent of the others and each block test only covers material contained within that block. In this case, the criterion may best be established at the end of the training block in which tailoring will be conducted. In this example, tailoring is envisioned for block 3 and the criterion based on its associated test at point A.

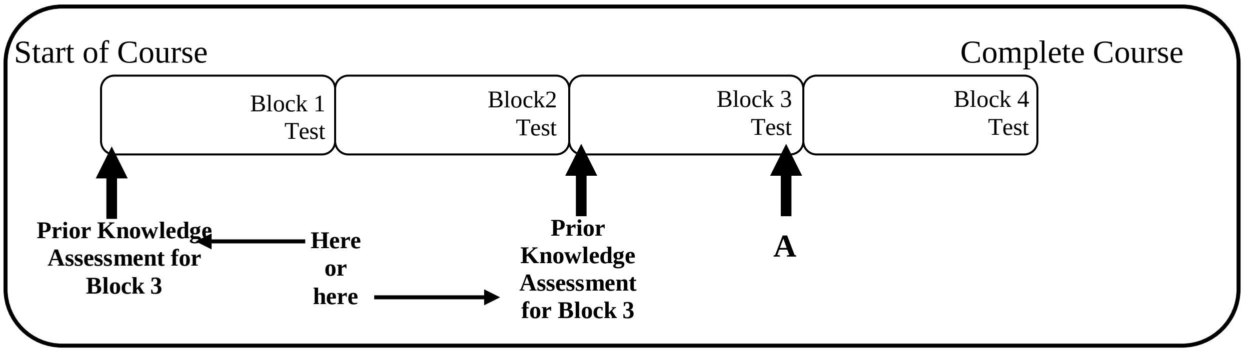


Figure 2. Course Y - independent blocks of training.

A prior knowledge assessment is only as good as its ability to provide an indication of how students are likely to perform on the criterion measure. As such, assessments used to predict performance must first be validated to determine if there is a relationship between performance in the assessment and on the criterion measure you identified. This is the heart of the validation process. In simple terms, a validated assessment is one where the presence of prior knowledge, as indicated by the assessment scores, provides an indication of what the related criterion measure score would be. Thus, criterion measurements should include measurements only related or potentially impacted by the presence of prior knowledge.

Training institutions have various ways in which students are evaluated on their course performance while in training. Some of those evaluations include performance measurements which may not be affected by the prior knowledge areas covered in the assessment. For example, many courses include student performance on a physical fitness test in the final course grade. Since physical ability is most likely not linked to the prior knowledge, the criterion selected for comparison should not include the physical fitness test performance.

To continue the example of maintenance training for tracked vehicle mechanics described in Chapter 2, step 3 of assessment development, recall that the instructor decided to assess student prior knowledge of tools and electrical wiring. In preparation for validation, suppose the assessment was given at the beginning of training and each student received an assessment score. It is now the end of training. To validate the assessment, student performance must now be measured in order to make a comparison. In this particular training course the students were given an overall rating based on the combined scores of written tests, hands-on tests, Army Physical Fitness

Test (APFT) scores, and an instructor subjective participation score. Should this overall rating of combined scores be used for comparison? The answer is “no”. Prior knowledge of tools and electrical wiring has no effect on how well students score on the AFPT and little to do with how well they participate in training. The assessed prior knowledge will be related to at least some of the written or hands-on tests. Therefore, what performance measurement (criterion) should be used? In this case, only the written or hands-on tests that are directly maintenance related should be used. An appropriate criterion may be the combination of all maintenance related test scores including written and hands-on tests.

If an assessment related criterion is not available as a matter of practice for any particular training, you will have to create a measurement in order to validate the assessment. Possibilities include separating out test scores or other measurements for material impacted by prior knowledge from those that do not apply or by introducing a post-training measurement or knowledge check that currently does not exist. In any case, in order for the assessment to be worthwhile, the criterion must be based on course objectives and requirements potentially impacted by the knowledge areas covered in the prior knowledge assessment.

You should also determine not only what the criterion will be but also how it will be quantified. Measurements identified with a number such as a percentage or a score tend to be more useful for comparisons than other less quantifiable measurements such as in a dichotomous “Go/No-Go” or “Pass/Fail” system. Dichotomous measurements simply indicate whether or not a student met the objective, but they give no indication of how well or how poor the objective was met. Measurements that give an indication of the degree of how good or how bad a student performs are more useful for comparison purposes than simple Go/No-Go measurements.

Dichotomous Criterion Measurements

There may be some training courses or instances where dichotomous measurements are the only available or reasonable alternative for establishment of a criterion. You should keep in mind that there may be creative ways to turn simple measurements into more quantifiable ones. For example, two students passed two hands-on tests during a block of training. Student #1 passed the first test on his first try, but it took him two tries to pass the second. Student #2 took three tries to pass the first test and four tries to pass the second. A simple calculation using this information could be performed to provide a more complete assessment of students’ performance.

	Student #1	Student #2
Number of tests	2	2
Total number of attempts	3	7
Overall percent correct	(2/3 = 67%)	(2/7 = 29%)

While this score has no effect on whether the students pass the training or not, it does give a better indication of each student’s actual performance. Consideration should also be given to whether overall “Go/No-Go” or “Pass/Fail” scores can be evaluated in more detail to give a more precise indication of performance. For example, suppose a

student receives a “No-Go” on a particular test because the standard was not met. Further examination may reveal that the test was made up of 20 distinct steps. Although the student correctly performed 19 of the 20 steps, one critical step was performed incorrectly and an overall “No-Go” was given. Compare this to a student that receives an overall “No-Go” but performed 15 of the 20 steps incorrectly or a student who received a “Go” with 5 incorrect steps. Using data regarding the completion of steps or number of errors committed to compile a continuous numerical score, even within different categories of errors (i.e. procedural or critical) if the steps are weighted differently in the evaluation, could provide more sensitive data and further distinguish between actual performance of individual students.

Dichotomous measurements of final attempts fail to recognize occasions such as when a student struggles with the training during instruction but eventually passes after repeated tries. When using dichotomous measurements, you must use scores that best distinguish between student performances. For example, if you decide to use test results from the first hands-on test within a course for your criterion, then as a general rule of thumb you would need to use the first attempt test results for that test as your criterion measurement. In courses where students are retrained and retested until virtually all “Go’s” are achieved by all students, then using the final results would not distinguish one student from another as all students would eventually have the same score. Using first attempt results as a criterion better distinguishes between student performances and provides a more sound foundation for validating your prior knowledge assessment.

3.4 What is the Validation Procedure?

To validate an assessment you must conduct a statistical analysis to determine the relationship between the scores from the prior knowledge assessment and the criterion measurement obtained after training. This requires some mathematical calculations which can be accomplished using an Excel spreadsheet. Before creating a spreadsheet, you should ensure you have all of the required data.

Table 4 below provides steps to be used to validate an assessment for subsequent use in tailoring.

Table 4
Prior Knowledge Assessment Validation Steps

Validation Steps	
Step 1	Administer the Prior Knowledge Assessment • Administer the assessment • Instructor does not see the results • Instructor conducts training as usual • Collect criterion scores after training

Validation Steps	
Step 2	Obtain and Input data into an Excel spreadsheet • Obtain student names and/or roster numbers, prior knowledge assessment scores, criterion measurement scores • Create an Excel spreadsheet • Record three sets of data in the spreadsheet (name/roster number, assessment score, criterion score) • Check all data for accuracy
Step 3	Compute a correlation coefficient • Create correlation coefficient formula in the spreadsheet • Compute the correlation coefficient
Step 4	Evaluate the strength of the relationship between the two scores • Determine if the relationship is strong enough to support using the prior knowledge assessment to tailor training
Step 5	Plot the relationship between the two scores • Create scatter plot in Excel using input data • Examine the scatter plot for outliers and strength of the relationship

Step 1 – Administer the Prior Knowledge Assessment

To validate your assessment you must administer it to a group of students in the same manner as when using it for tailoring training. It should be administered within the first few days of training since the more students are exposed to training content the more influence their training can have on their results. The objective is to obtain an understanding of what prior knowledge each student enters the classroom with prior to any instruction, familiarization with training content, or knowledge shared by more confident, knowledgeable students. Consequently, the earlier the assessment can be administered the better.

In order to validate a prior knowledge assessment, you must have a sufficient number of students for training that will produce both prior knowledge assessment scores and criterion scores. Generally, as the number of students used in the validation process increases, the more reliable the conclusions are about the relationship of prior knowledge assessment scores to criterion scores. As a general rule, you should have at least 30 students who will be given the prior knowledge assessment and complete the training in order to validate the assessment. If the class size is less than 30, you may need to administer the prior knowledge assessment to more than one class and obtain criterion scores from all students.

Administer the assessment in the same way you would administer any closed-book, individual effort test or exam. Be careful not to downplay the importance of the assessment by overemphasizing that it will not be a part of the course grade as this may lead to students not performing to their full ability. Once the students have answered all the questions, collect the completed assessments.

The next action is extremely important. Once prior knowledge assessments are collected, they must be stored for use at the end of training. ***<u>The instructor</u>***

conducting the training should not score or view the results of the assessment during the validation process. If needed, they can be administered and/or stored/scored by you the developer or another training administrator or supervisor and the results secured appropriately. The key point is for instructors not to view the results until the end of training to ensure they do not inadvertently allow that knowledge to alter training during the validation trial. Ultimately, the assessment results will be used to enhance student performance; however, not before the assessment instrument has been validated. The training for this block or course should be conducted in exactly the same manner as usual, as if the initial assessment had never been administered.

At the completion of the training block or course, you are ready to validate your assessment. You will now need to compute, collect, and record the criterion results according to your plan for obtaining those scores. After the criterion measure has been administered, the prior knowledge assessment can now be scored as well. Thus, each student should have a prior knowledge assessment score and a performance based criterion score. Student results that do not contain both sets of scores, for any reason, must not be used in validation. You now have all of the information you need to validate the assessment: students' identity or name, prior knowledge assessment scores, and criterion scores.

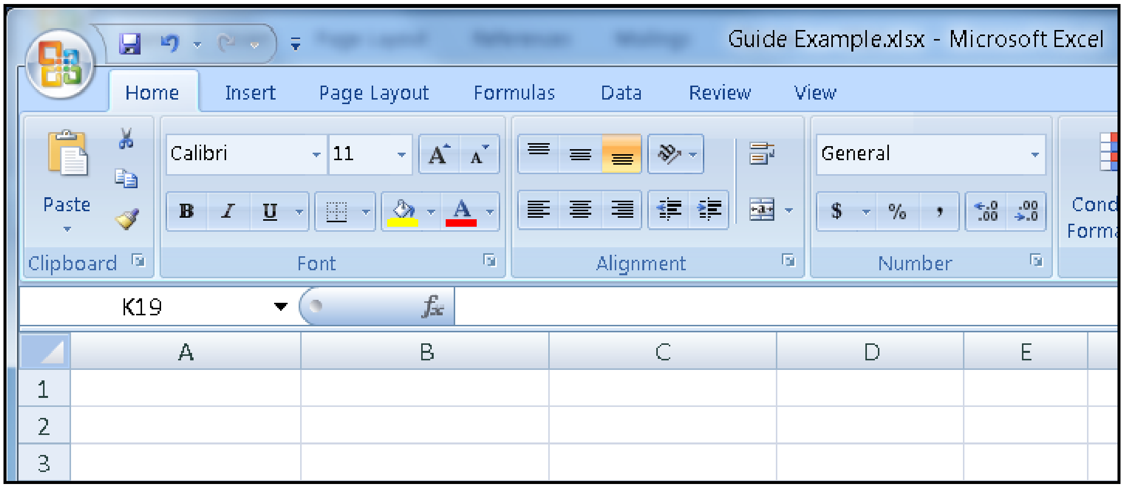
> *Note: While there are a great number of different statistical programs, e.g. SPSS, that could be used during this process, they require special permissions to load on a government computer, additional resources to purchase, and additional training in their operation. Since Excel is part of the Windows Office suite loaded onto nearly every Army computer, it's readily available to all personnel and nearly everyone has at least some familiarity with its functions.*

Step 2 – Obtain and Input Data Into an Excel Spreadsheet

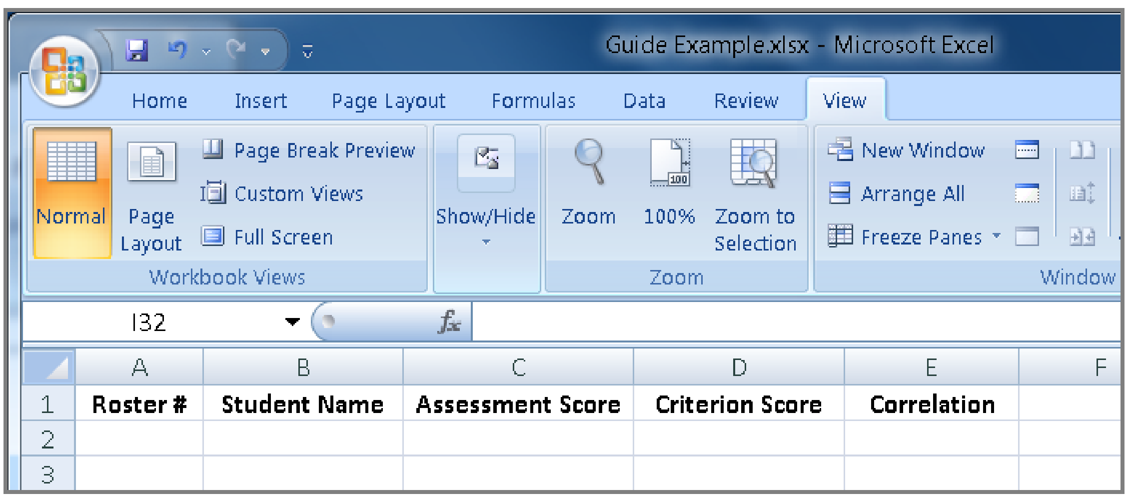
After obtaining prior knowledge assessment and criterion scores from all of the students, you are ready to input the data into an Excel spreadsheet. The following procedures will explain each step. Appendix C contains sample exercises for the Excel procedures explained below.

Using the procedures below carefully input and double check all student data.

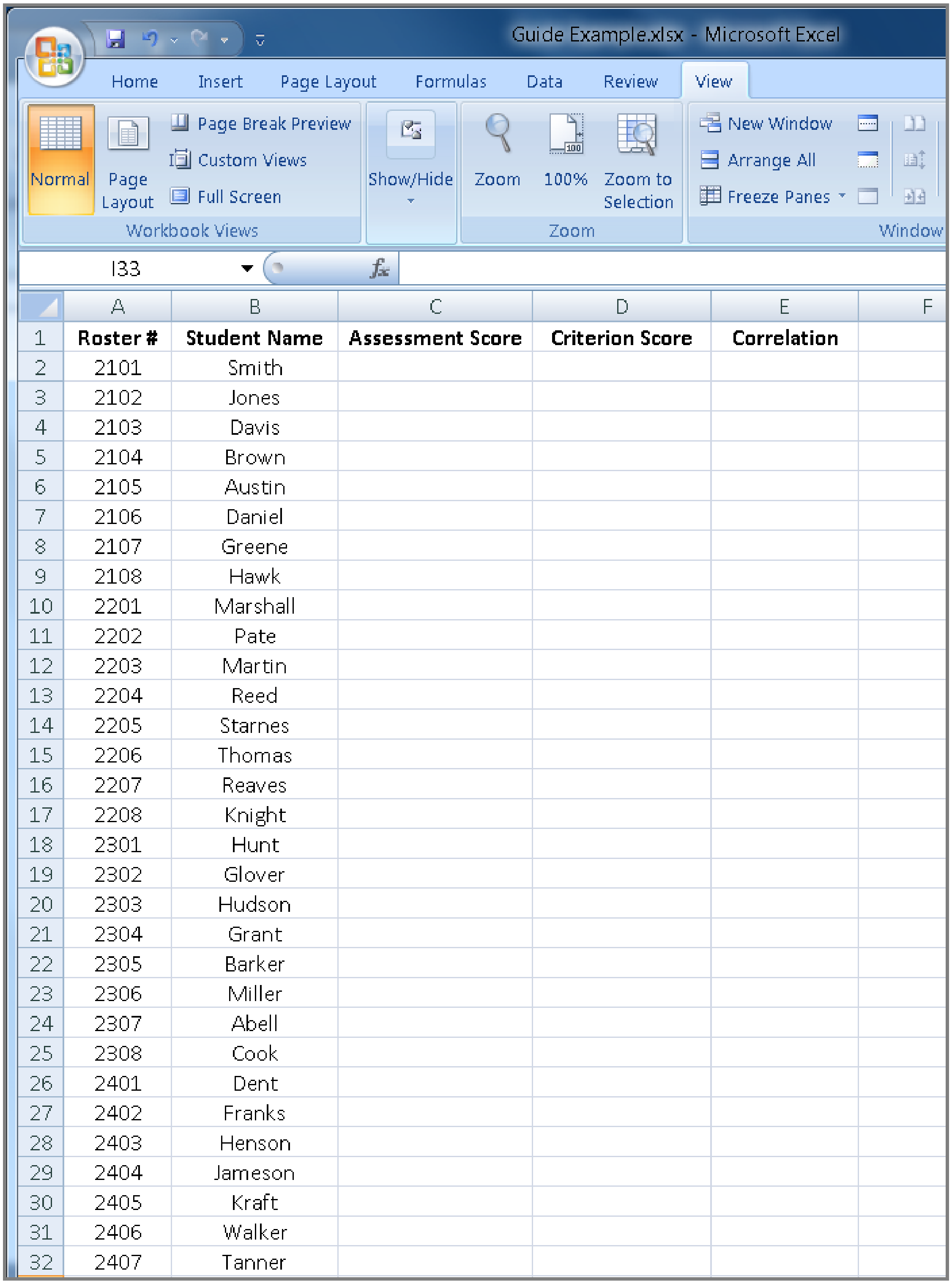
1. Open MS Excel to a blank worksheet.



2. Label columns “A”, “B”, “C”, “D”, and “E” of row one; Roster #, Student Name, Assessment Score, Criterion Score, and Correlation.

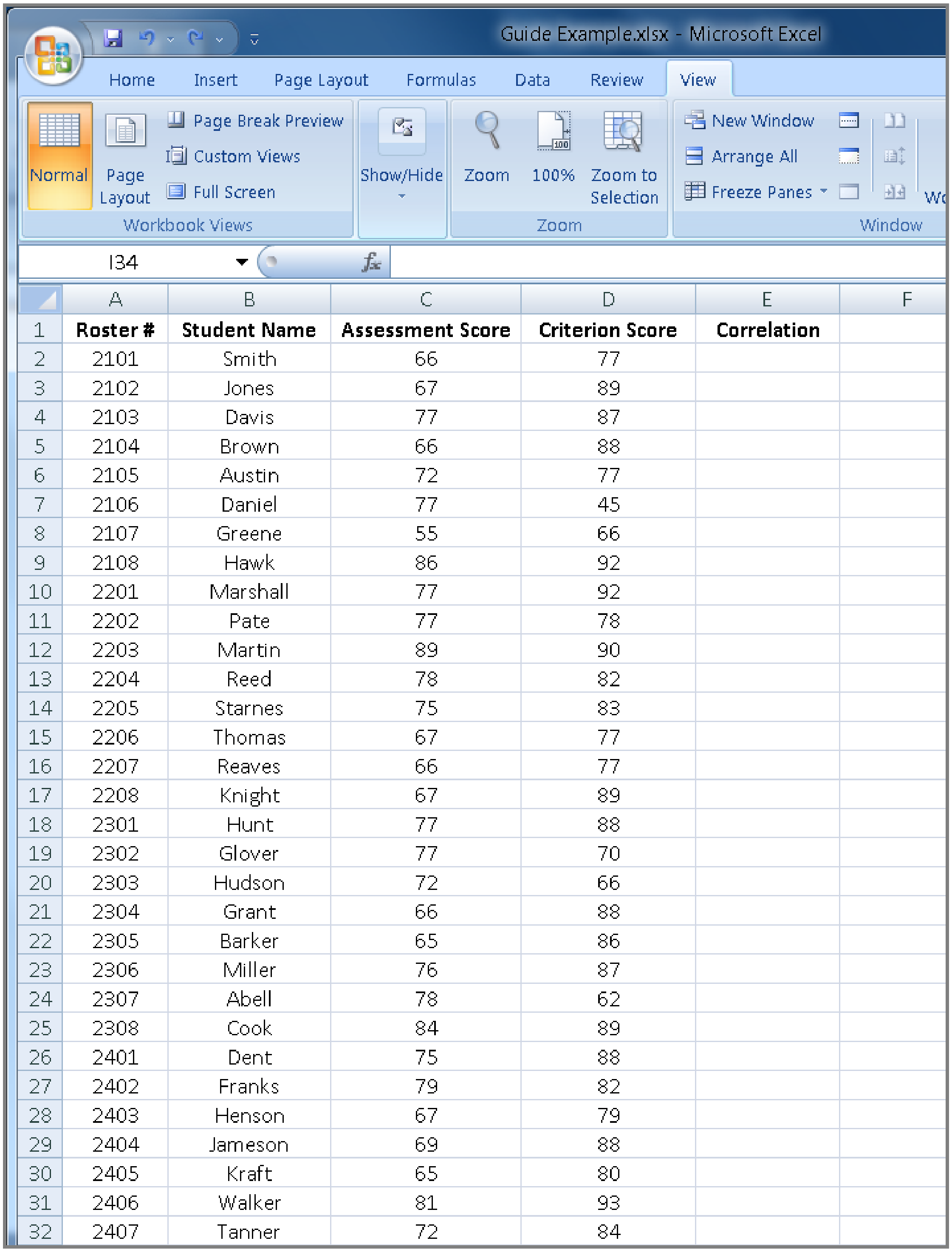


3. Identify students by roster number and/or name.



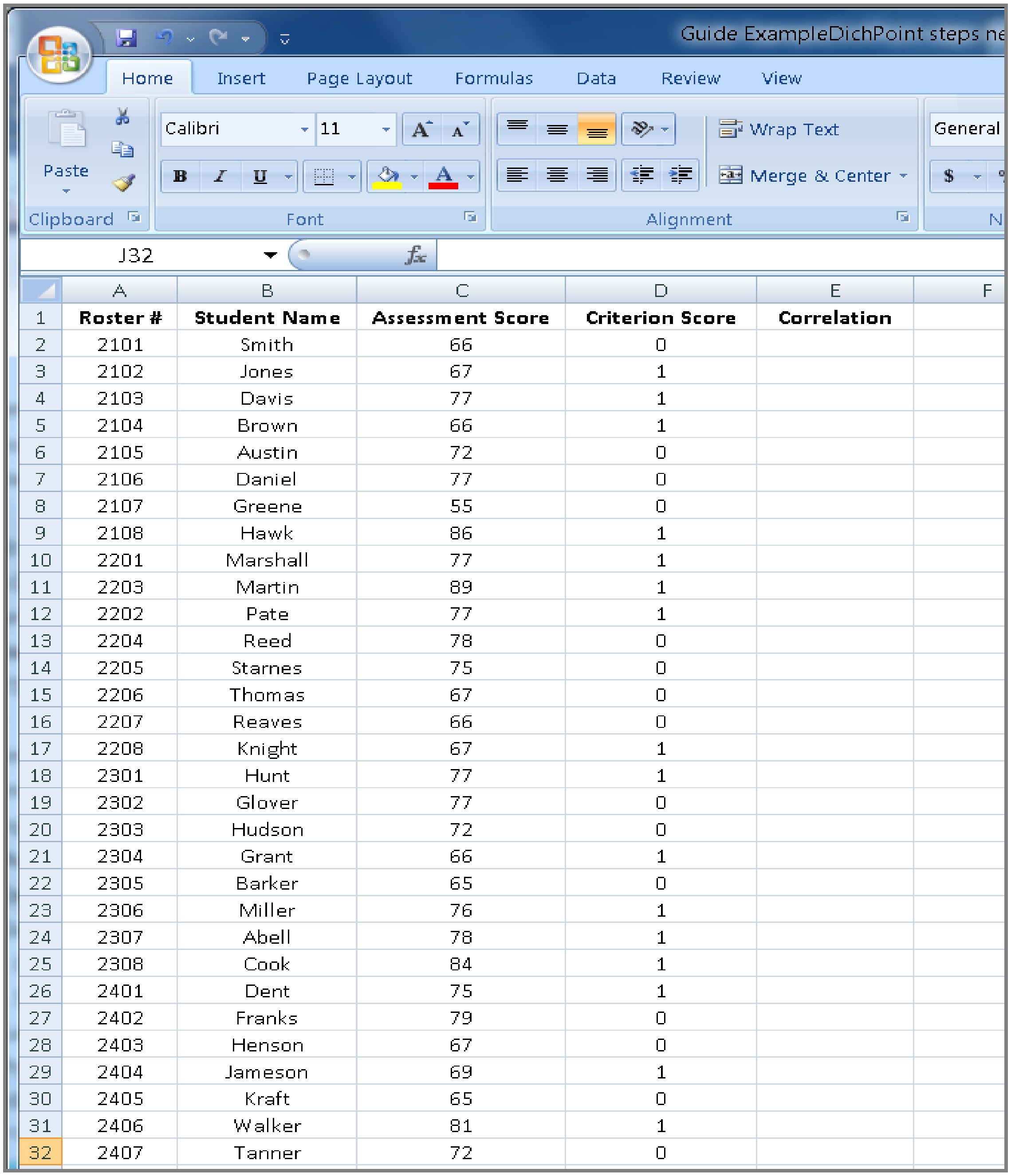
Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2101	Smith			
2102	Jones			
2103	Davis			
2104	Brown			
2105	Austin			
2106	Daniel			
2107	Greene			
2108	Hawk			
2201	Marshall			
2202	Pate			
2203	Martin			
2204	Reed			
2205	Starnes			
2206	Thomas			
2207	Reaves			
2208	Knight			
2301	Hunt			
2302	Glover			
2303	Hudson			
2304	Grant			
2305	Barker			
2306	Miller			
2307	Abell			
2308	Cook			
2401	Dent			
2402	Franks			
2403	Henson			
2404	Jameson			
2405	Kraft			
2406	Walker			
2407	Tanner			

4. Input assessment and criterion scores for each student. Double check your input data for errors. It may be worthwhile to have a separate individual check all the data after it has been entered. Be sure that both scores are matched to the correct student. The example below shows criterion scores based on continuous numerical measurements exhibiting a range of scores.



	A	B	C	D	E	F
1	**Roster #**	**Student Name**	**Assessment Score**	**Criterion Score**	**Correlation**	
2	2101	Smith	66	77		
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		

5. If your criterion measurement is in the form of dichotomous measurements (i.e, measures with only possible outcomes) your criterion scores, such as “Go / No-Go” or “Pass /Fail”, will have to be converted into a number in order to enter them into Excel for further computations. In order to do this you will need to convert all of one type score into “1’s” and all of the other type into “0’s”. “1’s” normally are associated with “Go” or “Pass” and “0’s” with “No-Go” or “Fail”. In this case all “Go” or “Pass” scores would be converted to a “1” and all “No-Go” or “Fail” scores would be converted to a “0”. Use these numbers for criterion scores for each student. The example below shows how those scores would be entered.



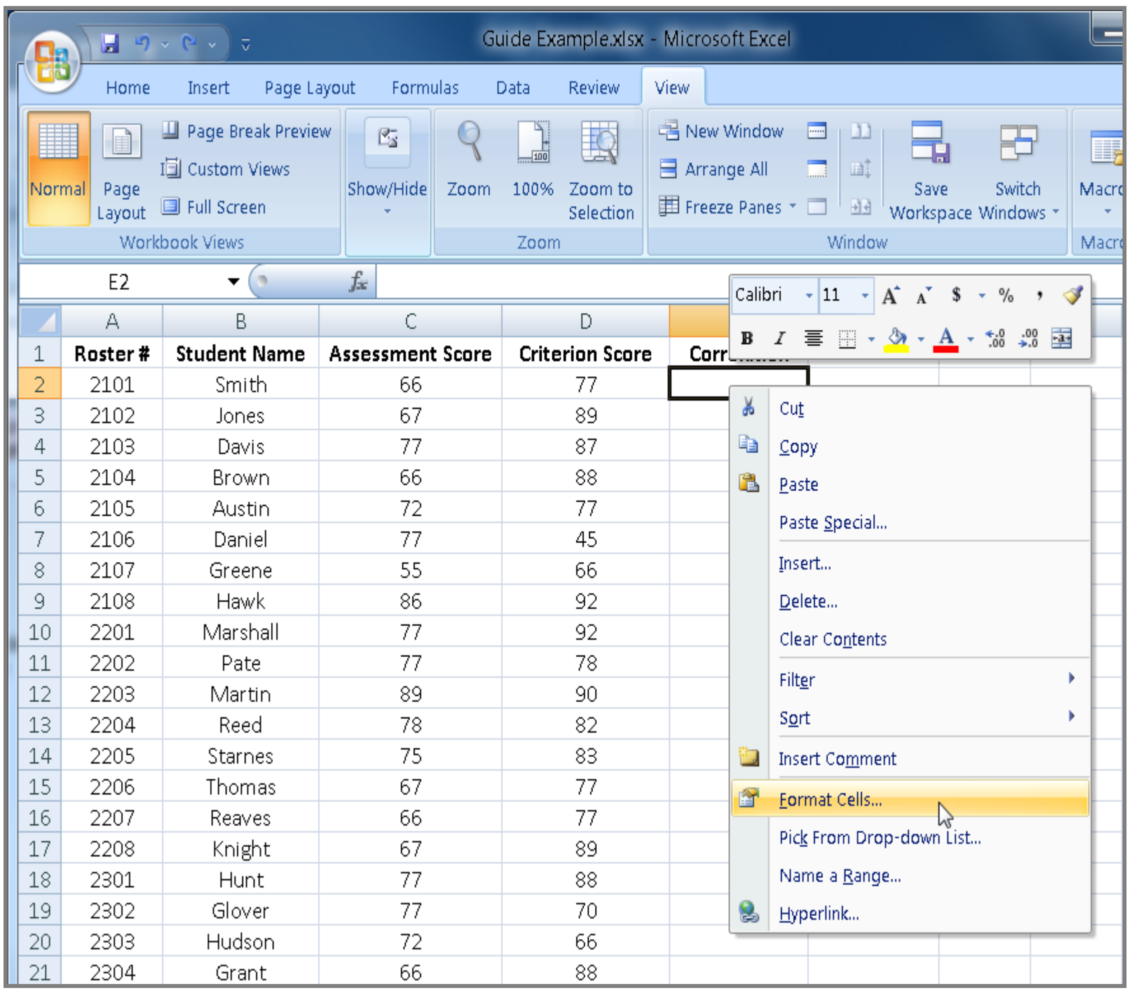
	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	0		
3	2102	Jones	67	1		
4	2103	Davis	77	1		
5	2104	Brown	66	1		
6	2105	Austin	72	0		
7	2106	Daniel	77	0		
8	2107	Greene	55	0		
9	2108	Hawk	86	1		
10	2201	Marshall	77	1		
11	2203	Martin	89	1		
12	2202	Pate	77	1		
13	2204	Reed	78	0		
14	2205	Starnes	75	0		
15	2206	Thomas	67	0		
16	2207	Reaves	66	0		
17	2208	Knight	67	1		
18	2301	Hunt	77	1		
19	2302	Glover	77	0		
20	2303	Hudson	72	0		
21	2304	Grant	66	1		
22	2305	Barker	65	0		
23	2306	Miller	76	1		
24	2307	Abell	78	1		
25	2308	Cook	84	1		
26	2401	Dent	75	1		
27	2402	Franks	79	0		
28	2403	Henson	67	0		
29	2404	Jameson	69	1		
30	2405	Kraft	65	0		
31	2406	Walker	81	1		
32	2407	Tanner	72	0		

Note: The procedures in Steps 3 through 5 are the same for data containing both continuous numerical and dichotomous measurements.

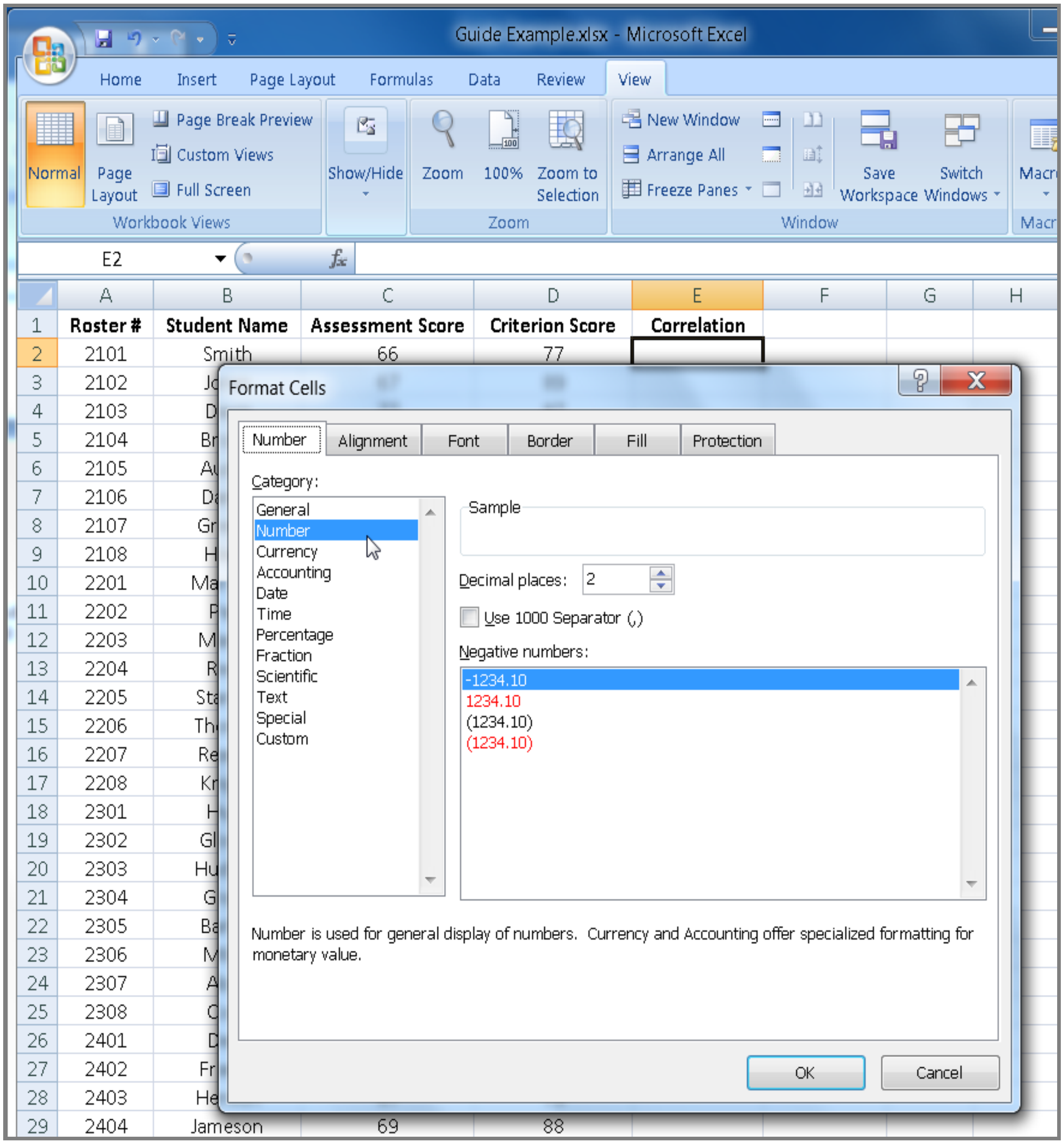
Step 3 – Compute the Relationship Using Excel

After entering the data you will need to enter the proper formula into Excel in order to compute a relationship in the form of a correlation coefficient. A correlation coefficient is easily calculated using Excel. Use the following procedures to compute a correlation coefficient from the data you entered. The example below shows continuous numerical measurement data.

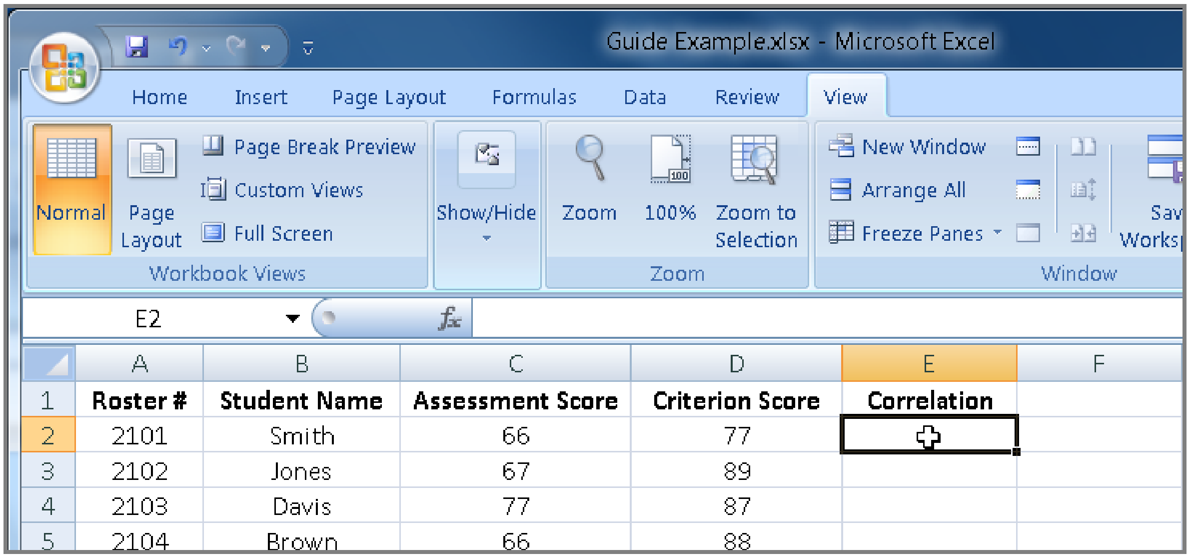
1. Position the cursor in cell “E2” underneath “Correlation” and click the right mouse button. This will bring up a menu. With the left mouse button click on “Format Cells”.



2. This will bring up a new menu. Make sure the “Number” tab is selected from the tabs at the top of the menu and with the left mouse button click on “Number” underneath “Category:” Ensure “Decimal places:” are set at “2” and with the mouse button left click on “OK” at the bottom of the screen.

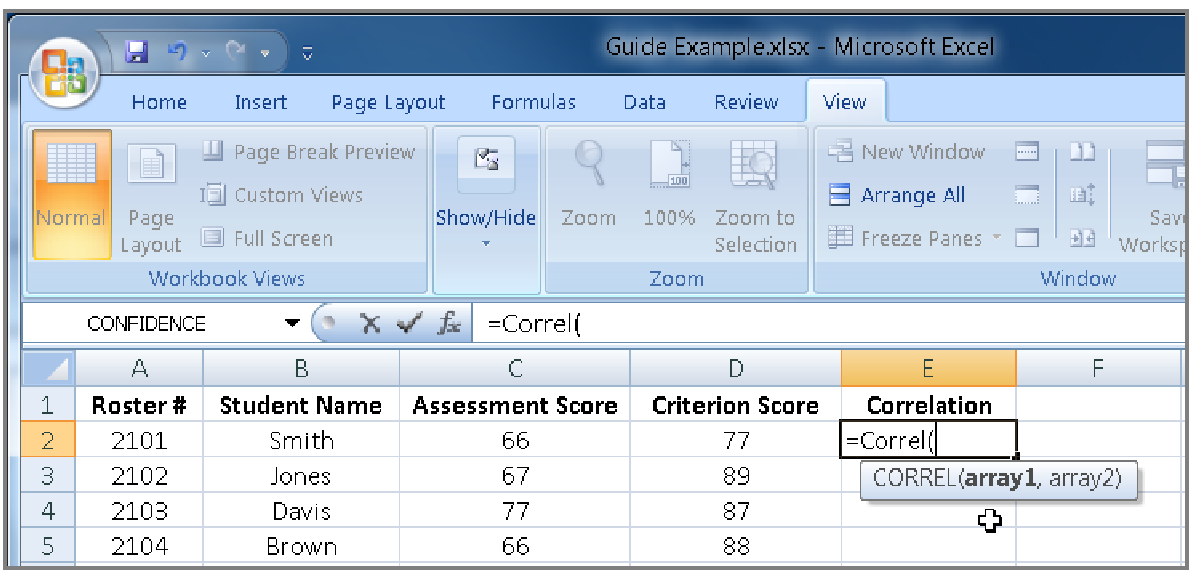


3. Position the cursor back in cell “E2” underneath “Correlation” and click the left mouse button ensuring cell “E2” is highlighted with a bold box.

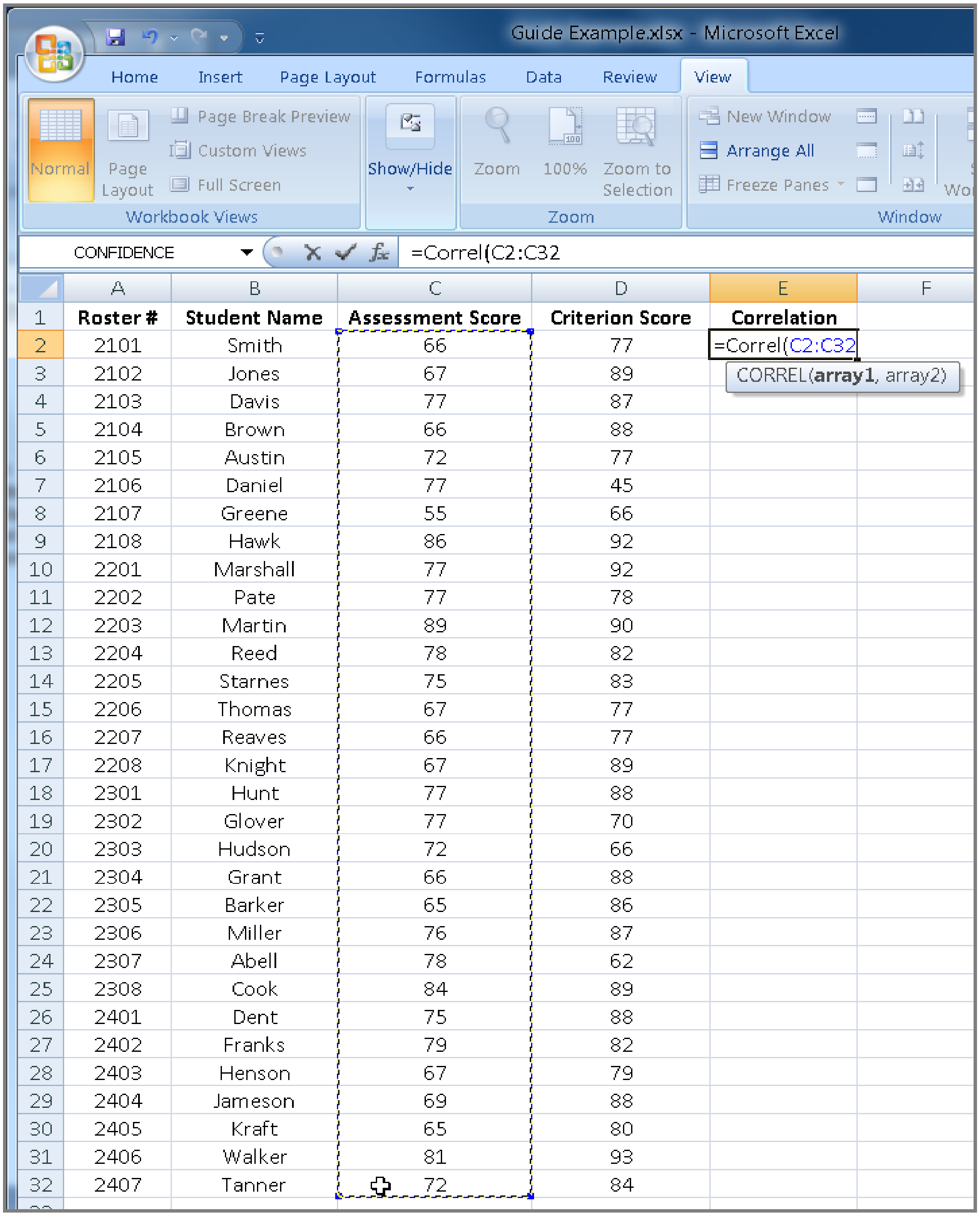


4. Type the following: =CORREL(

As you type you will see “CORREL(**array 1**,array 2)” appear with “**array 1**” in bold print near cell “E2”.

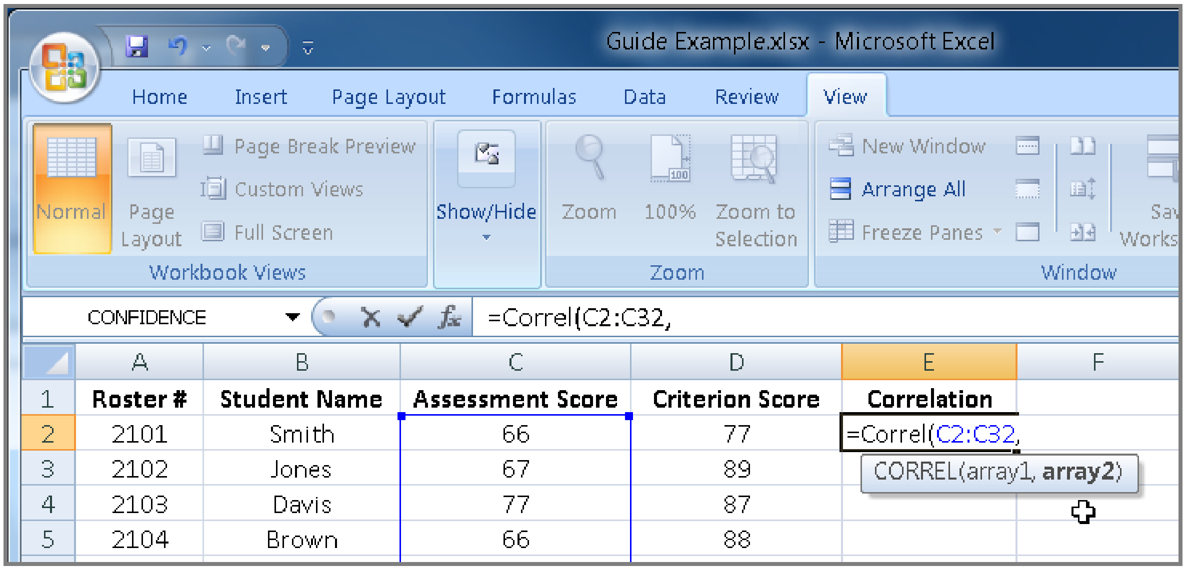


5. With “**array 1**” in bold print, move your cursor and click on the first number in column “C” with the left mouse button and without releasing the mouse button drag the cursor to the last number in column “C”. Now release the mouse button and this will draw a box around the assessment scores in column “C” only. Make sure you only include the scores in column “C” with no extra spaces at the end and do not include the title. As you drag the cursor you will see the cell positions for “**array 1**” automatically record in your function.

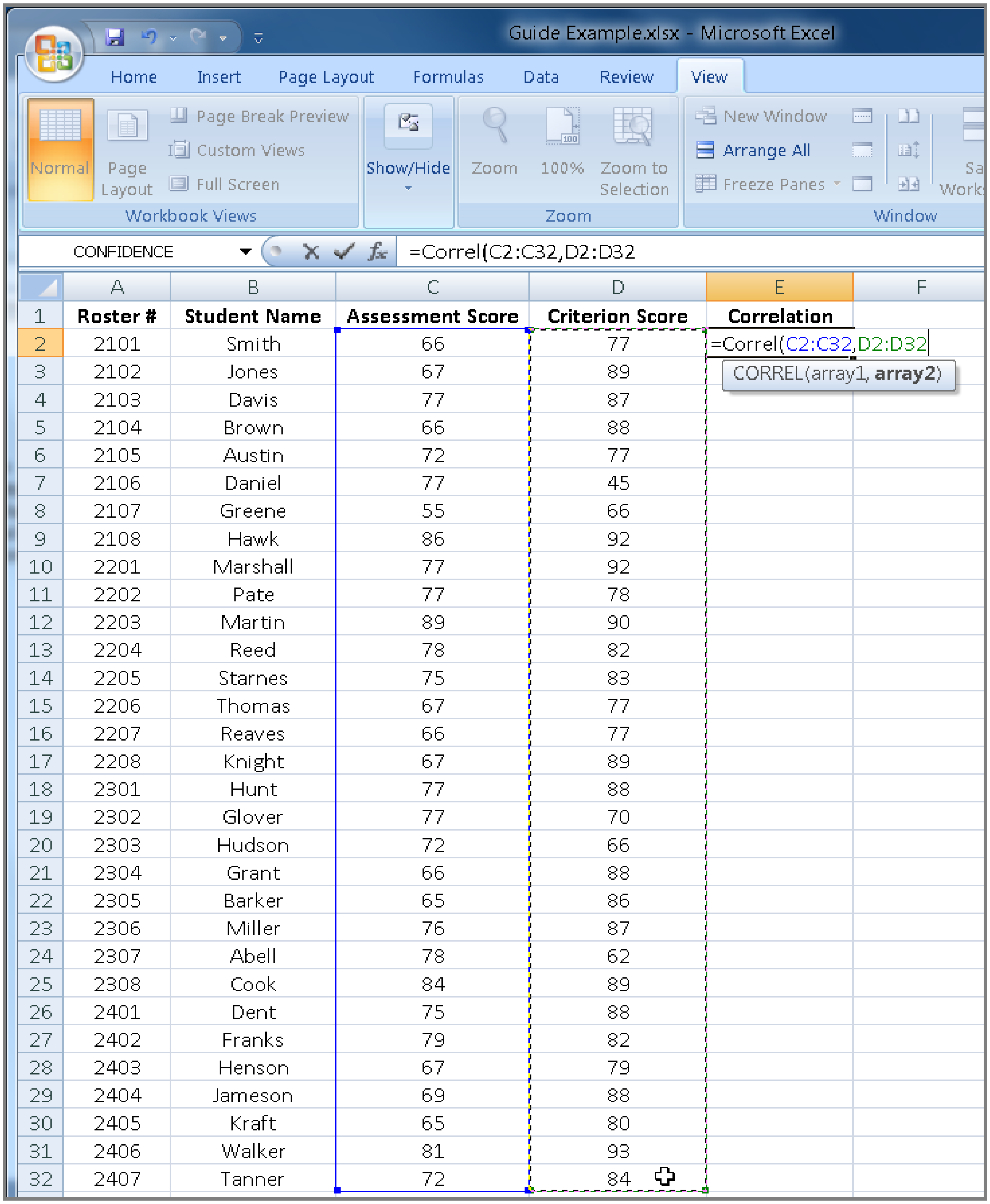


	A	B	C	D	E	F
1	**Roster #**	**Student Name**	**Assessment Score**	**Criterion Score**	**Correlation**	
2	2101	Smith	66	77	=Correl(C2:C32	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		

6. Type a comma (,) and "array2" will automatically show in bold type.

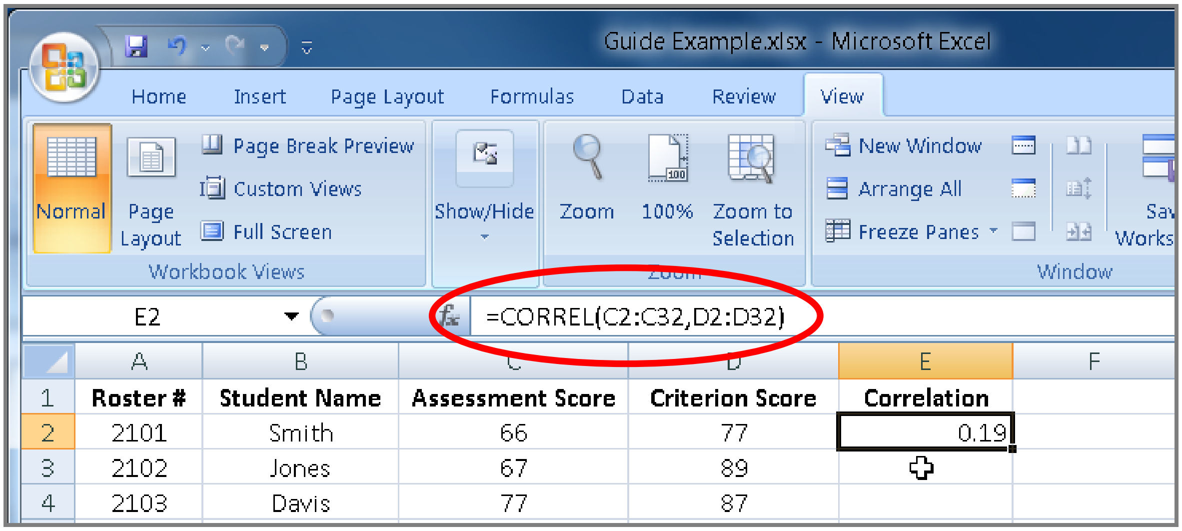


7. With “**array 2**” in bold print, take your cursor and click on the first number in column “D” with the left mouse button and without releasing the mouse button drag the cursor to the last number in column “D”. Now release the mouse button and this will draw a box around the assessment scores in column “D” only. Make sure you only include the scores in column “D” with no extra spaces at the end and do not include the title. As you drag the cursor you will see the cell positions for “**array 2**” automatically record in your function.

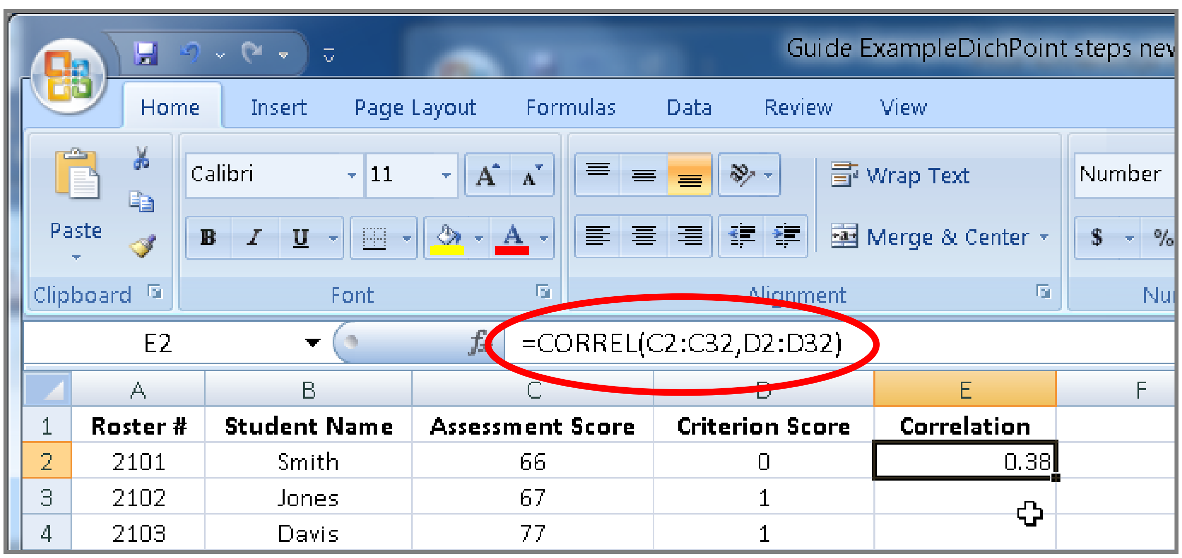


	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	=Correl(C2:C32,D2:D32	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		

8. Hit the “Enter” key on your keyboard and the correlation for your assessment will automatically be calculated and displayed in the cell in which you typed the function. The final formula should appear as shown.



9. If your data includes dichotomous measurements the correlation coefficient formula is entered in the same manner as shown in the example below.



10. Observe the correlation coefficient and once again check for any errors during input of data or functions. If you receive an error message while entering the function, delete what you have entered and attempt to reenter it using the steps above. If you are not familiar with Excel and are having difficulty you may need to ask for assistance from someone more familiar with the program. Once you have obtained your correlation coefficient proceed to Step 4 for evaluation of the value you obtained.

Note: Additional instructions in Appendix B include procedures for adding, changing, and deleting input data.

Step 4 – Evaluate the Strength of the Relationship Between the Two Scores

The correlation coefficient you calculate between the prior knowledge assessment score and the criterion score reflects the relationship between the two scores and will range between -1.0 and + 1.0. So what does this mean?

- Positive correlation coefficients mean that high scores on one measure are associated with high scores on the other, and low scores on one are associated with low scores on the other. Positive values between 0.0 and 1.0 indicate a positive relationship.

- Negative correlation coefficients mean that high scores on one measure are associated with low scores on the other, and that low scores on one are associated with high scores on the other. Negative values between -1.0 and 0.0 indicate a negative relationship between the measurements.

- A correlation coefficient of 0.0 means that scores on one measure do not indicate the magnitude of scores on the other and there is no association between the two scores. Values at or near 0.0 indicates there is no relationship between the measurements.

Although both positive and negative relationships are possible, in general, for your purposes, the correlations you will obtain will fall between 0 and +1. In other words, you will probably have instruments where high assessment scores reflect good performance and high criterion scores reflect good performance as well. The closer the correlation is to +1, the stronger the relationship. This indicates less error in prediction from your prior knowledge assessment to the criterion measure. For example, if instructors are interested in providing additional assistance to students likely to struggle with the training, a strong relationship indicates less error involved in identifying early on the students requiring that assistance.

After determining the correlation coefficient, you need to evaluate the value obtained to determine if the strength of the relationship between a student's prior knowledge and subsequent performance is strong enough to validate the assessment's usefulness. Higher correlation values indicate better relationships and more confidence in forecasting outcomes while values close to 0.0 indicate less of a relationship and less confidence.

Generally correlation coefficients that involve performance scores fall somewhere between 0.3 and 0.5 with correlations between 0.5 and 1.0 possible but seen much less often. Values less than 0.3 are generally considered weak relationships and the assessment's usefulness as a predictor is suspect.

As a rule of thumb to guide you, once you have obtained a correlation coefficient of 0.3 or above, your prior knowledge assessment provides a sufficiently strong relationship to the criterion to make decisions regarding individual differences and tailored training. However, higher values of the correlation will enable instructors to make more sound decisions regarding individuals. Once you have validated your assessment, it may be used for subsequent tailored training to target students the assessment was designed to identify.

If the correlation coefficient falls below the acceptable limit, the assessment will most likely need to be altered. Consideration should then be given to a reanalysis of either the knowledge areas chosen for the assessment or of the questions asked within each area. See Chapter 4 of this guide for further guidance on assessments that are not validated.

Student scores can also be reflected on a graph for a clearer view of the relationship. A perfect relationship means that if you know the value of one score you can accurately predict the value of the other score and are indicated with correlation coefficients at the extremes of +1.0 and -1.0. Strong relationships are represented by numbers near -1.0 or 1.0. Weak relationships are represented by numbers near 0.0.

The graphs in Figures 3, 4, and 5 below illustrate three correlations involving continuous numerical measurements (a positive correlation at or near +1.0, a negative correlation at or near -1.0, and no correlation at 0).

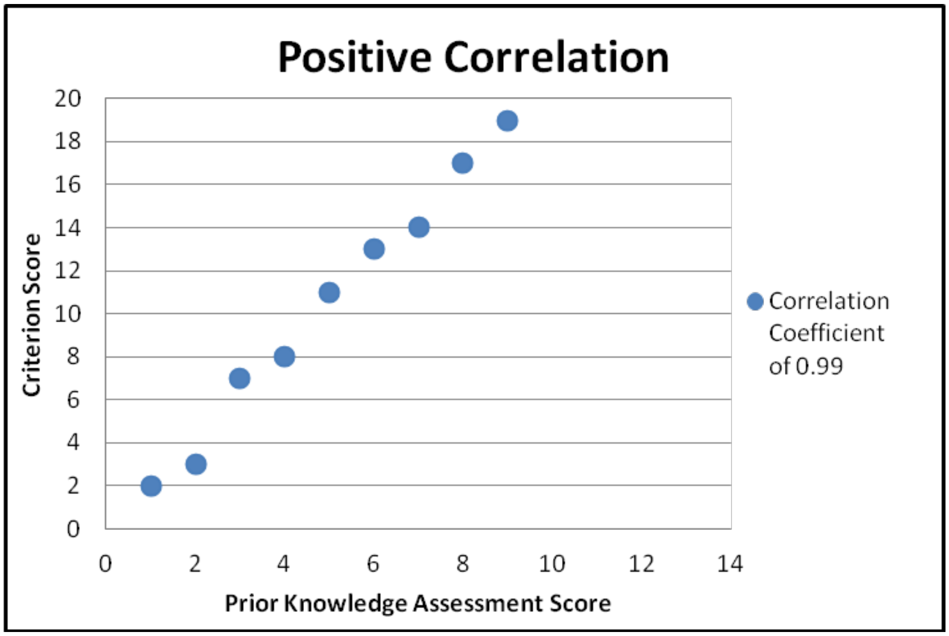


Figure 3. Positive correlation with continuous numerical measurements.

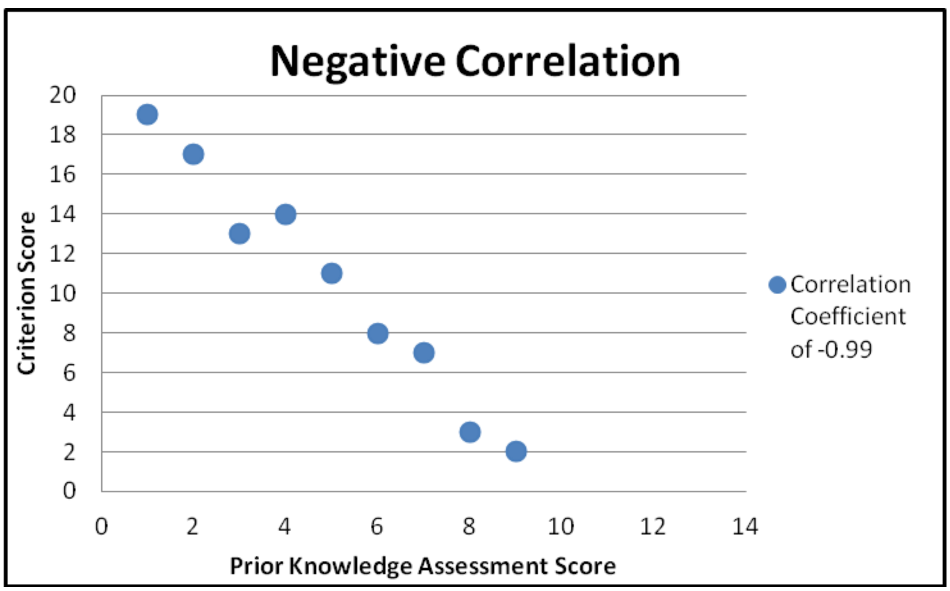


Figure 4. Negative correlation with continuous numerical measurements.

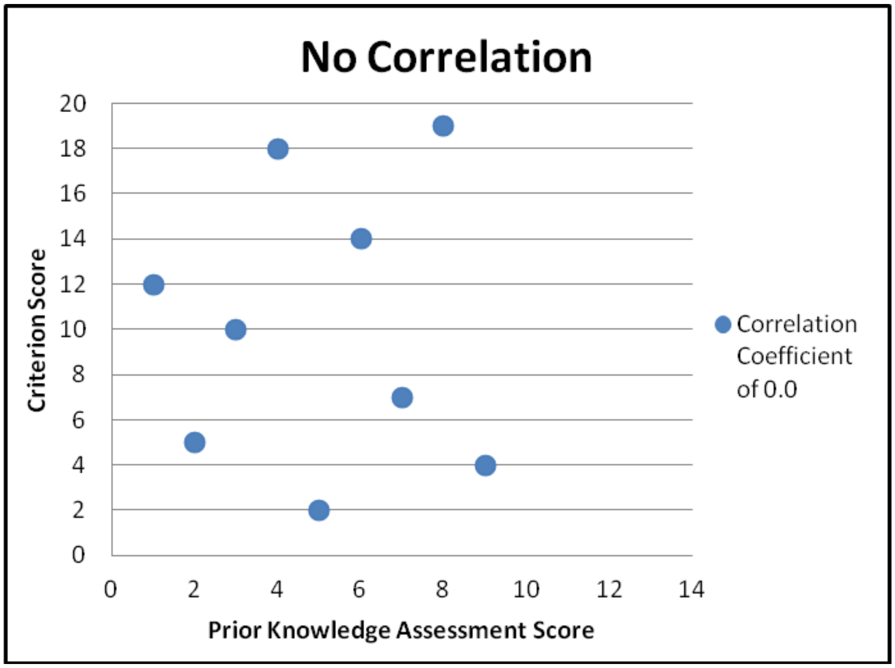


Figure 5. No correlation with continuous numerical measurements.

The graphs in Figures 6, 7, and 8 below illustrate three correlations involving dichotomous criterion measurements (a positive correlation at or near +1.0, a negative correlation at or near -1.0, and no correlation at 0).

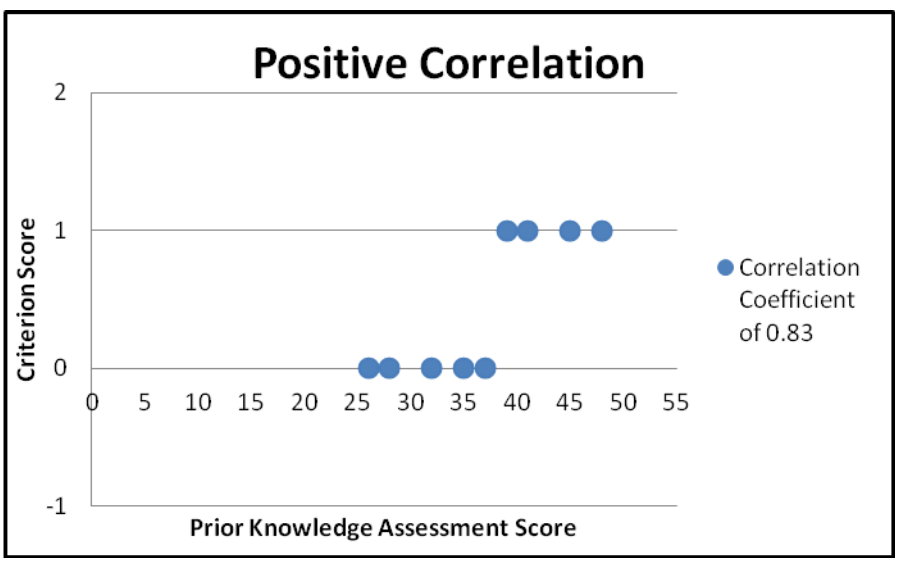


Figure 6. Positive Correlation with dichotomous criterion measurements.

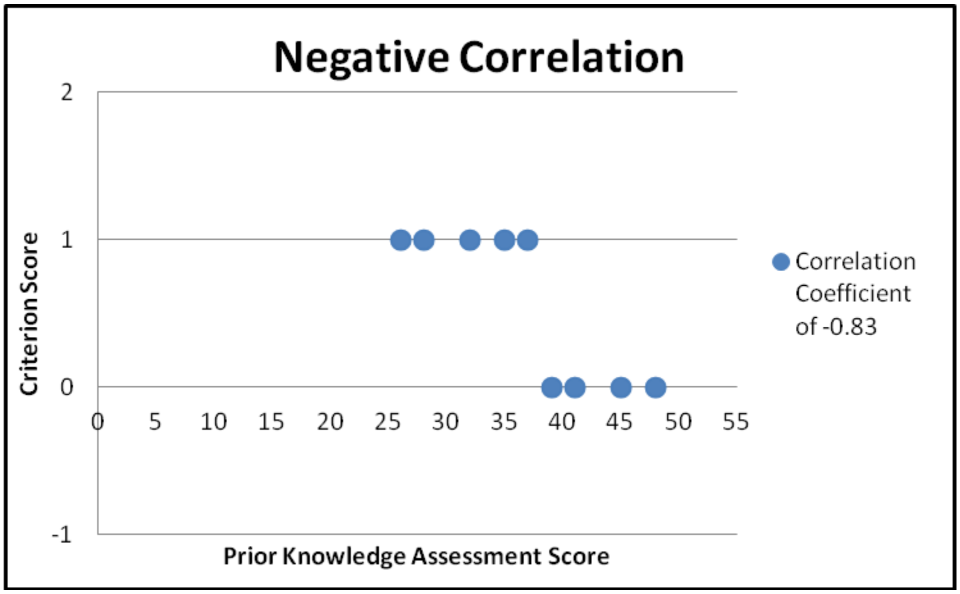


Figure 7. Negative correlation with dichotomous criterion measurements.

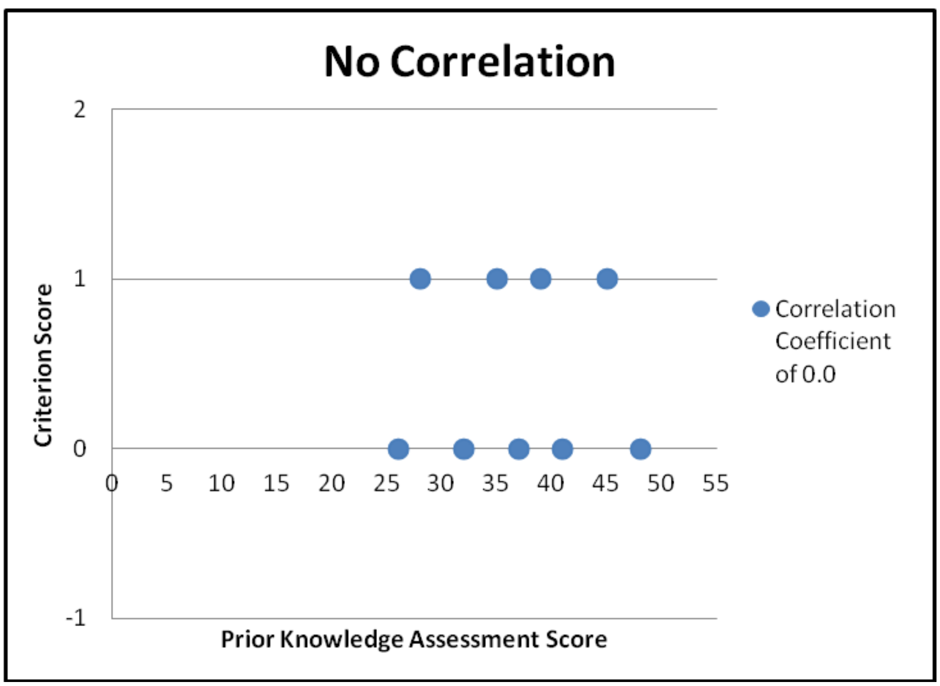


Figure 8. No correlation with dichotomous criterion measurements.

Step 5 – Plot the Relationship Between the Two Scores – Examine for Outliers

To help visually observe and further interpret your data, a scatter plot may be used. Scores for each student can be represented by a data point on a scatter plot graph with two axes where one axis represents the assessment score, and the other axis the criterion measurement. Each individual student's scores can be plotted on this graph by the representation of one data point. When all student data points are plotted, they generally form some type of cluster of data points whether that be small, large, circular, linear, or some other type of pattern.

For your purposes during validation, visualization of scores on a scatter plot can help you look for outliers. An outlier is a data point that for some reason does not fall within the reasonable limits or general cluster of the rest of the data points. Outliers can be caused by a wide variety of factors including, but not limited to: incorrect data entries, students outside the general population, incorrect data used for input entries, or external factors affecting the results of input data. Outliers can skew your analysis and provide results that may not truly represent the relationship of your measurements. For each outlier, a determination must be made of whether its associated data should be justifiably excluded. Once a scatter plot is produced, you should visually look for outliers. Consider the example in Figure 9.

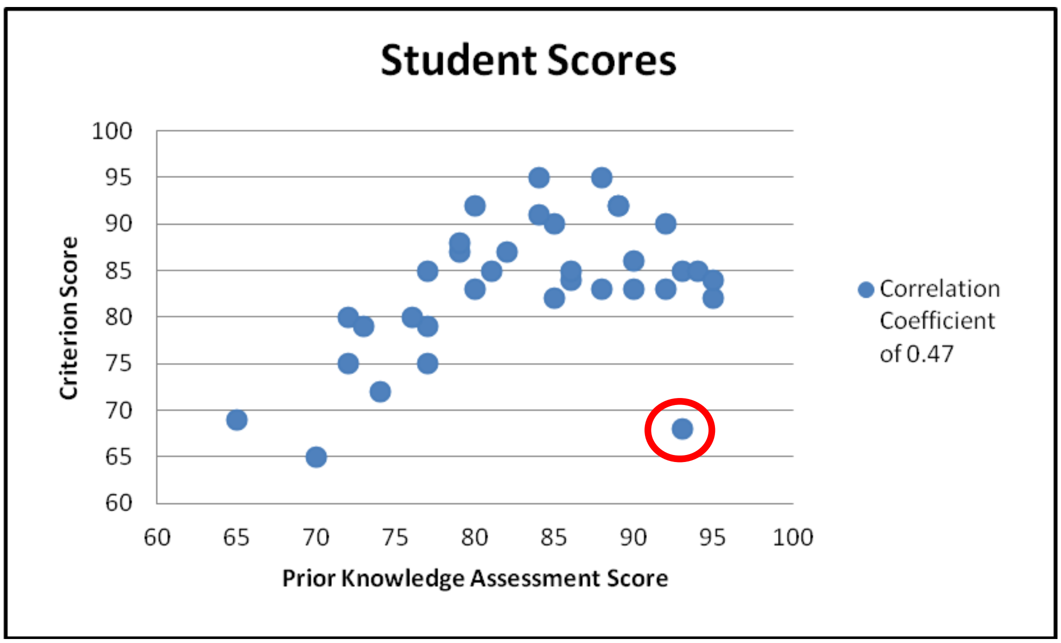


Figure 9. Relationship of student scores (continuous numerical criterion scores).

You will notice that the data points are plotted from data including continuous numerical criterion scores and generally cluster along a linear path sloping up and to the right with a correlation coefficient of 0.47. However, you should also note one data point falls well outside the cluster. This point would be considered an outlier. This is important because this inconsistency is likely due to some undetermined reason that may cause you to exclude that data point from your analysis. Inconsistent data points such as the

one above can cause inappropriate variations in the analysis. Once you have identified any possible outlier, you should then further analyze that particular point for contributing factors that would cause the outlier, other than what was measured by the assessments, and subsequently decide if that point should be excluded from the analysis.

For the outlier shown in Figure 9, you would normally expect that either the criterion measurement would be higher (between the mid 80's and mid 90's) or the assessment score would be lower (around mid 70's or below) in order to cluster with the other data points. A further analysis of that data point may reveal, as one possibility, that an input error was made. It could also reveal some other contributing factor. For example, if cumulative test scores were used as the criterion and a student was absent on some test days, the criterion score would be inaccurate. The missing scores would cause a low criterion measurement but would not necessarily be indicative of how that student would have performed had the tests been taken. This would be a logical reason for excluding that data point from the analysis. You may also consider excluding from the analysis those students who are not part of what would be considered the general population and may likely skew the data, e.g. allied students or students from other services who would be expected to lack the prior knowledge you are measuring.

You can also visually observe for outliers in scatter plot graphs that include dichotomous criterion measurements. Consider the graph in Figure 10 below.

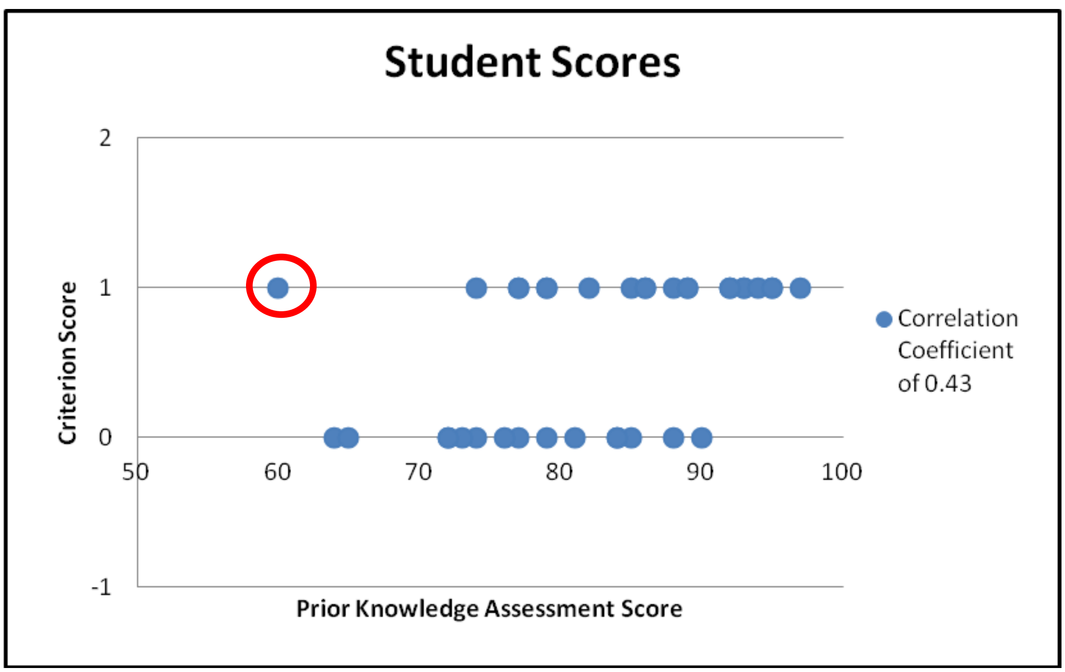


Figure 10. Relationship of student scores (dichotomous criterion scores).

You will notice that data points in Figure 10 generally cluster in one of two groups. Students that generally score lower on the assessment also tend to score lower on the

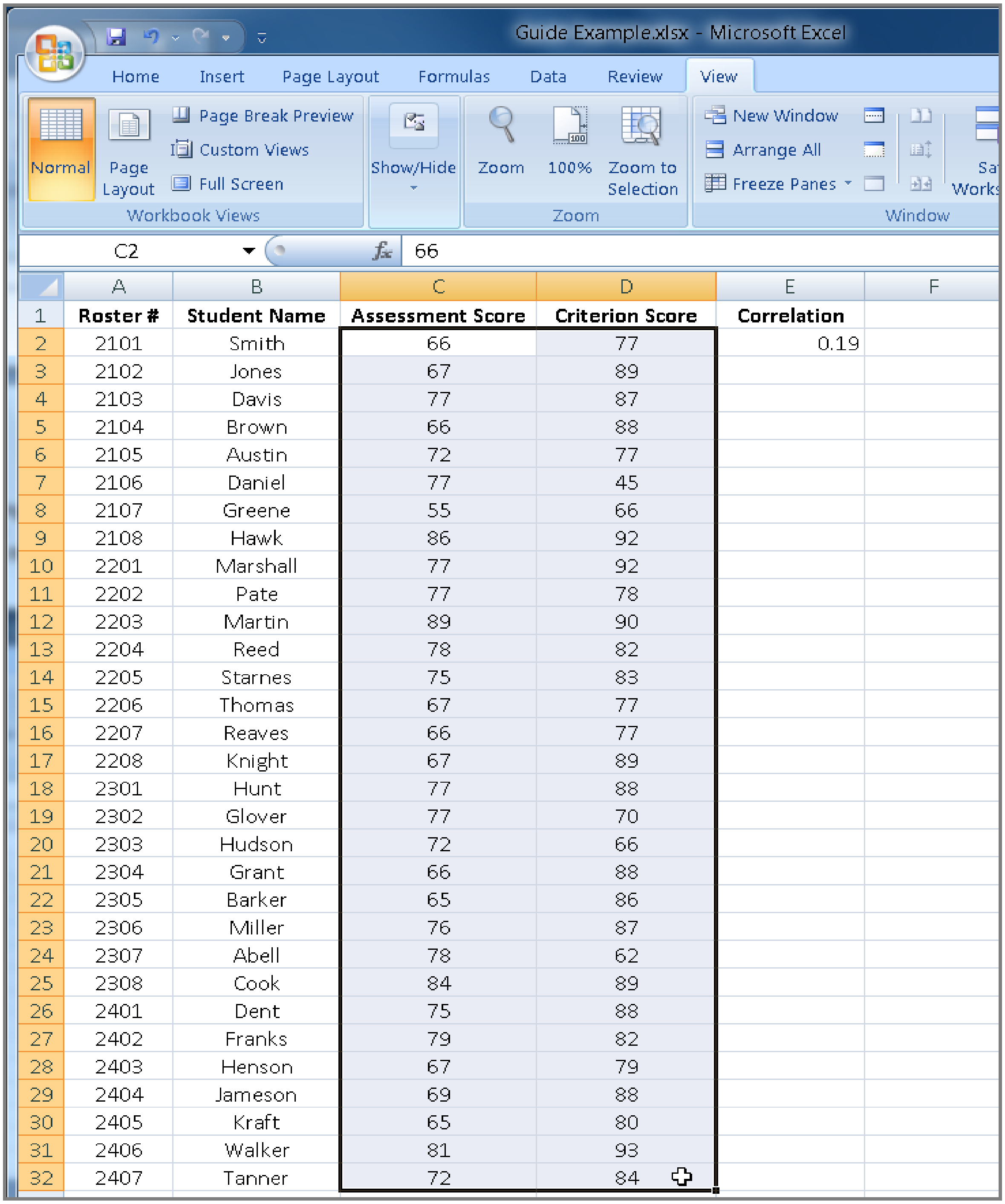
criterion. Students that generally score higher on the assessment also tend to score higher on the criterion. Outliers in this case would be seen as a data point falling outside one of these clusters. In Figure 10 one of data points is clearly outside of either cluster of points and may indicate an issue with that particular data.

When dealing with potential outliers, you must be careful not to exclude applicable data points for the sake of intentionally trying to alter your analysis in order to validate the assessment. Remember, the reason validation is necessary is to establish that there is a credible relationship between your measurements.

<u>Tweaking input data or excluding data points to intentionally alter your analysis can lead to faulty conclusions which could include targeting the wrong students for the tailored training you envision.</u>

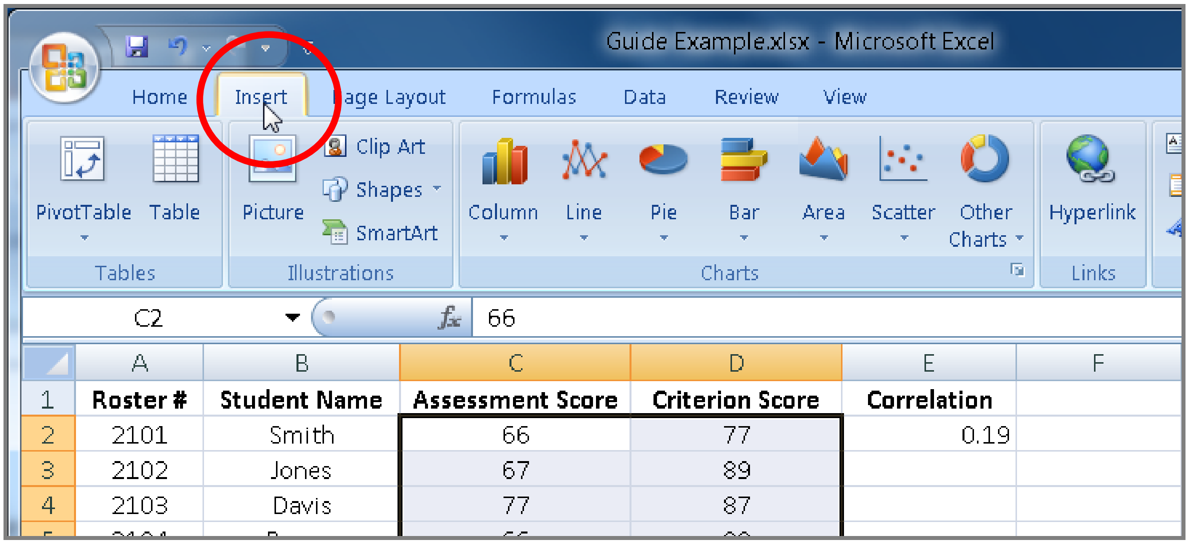
To create your own scatter plot using the data you entered into an Excel spreadsheet, use the following procedures.

1. To use the scatter plot function, draw a box around both sets of data by placing the cursor in the first cell of the assessment scores, cell “C2”, clicking the left mouse button, and without releasing the left mouse button drag the cursor to the last number of the criterion scores, in this example cell “D32”, and releasing the left mouse button. This will draw a box around all the numerical scores you have entered.

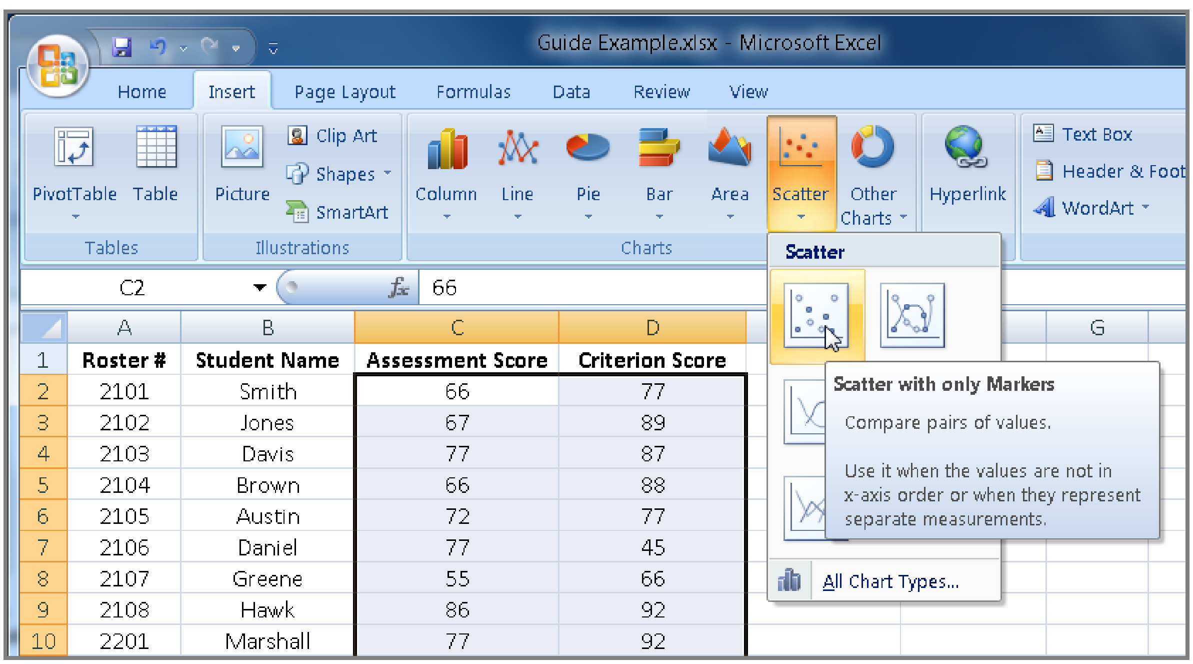


	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	0.19	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		

2. Once both sets of data are highlighted, click on the “Insert” tab near the top of the page to display the insert options.

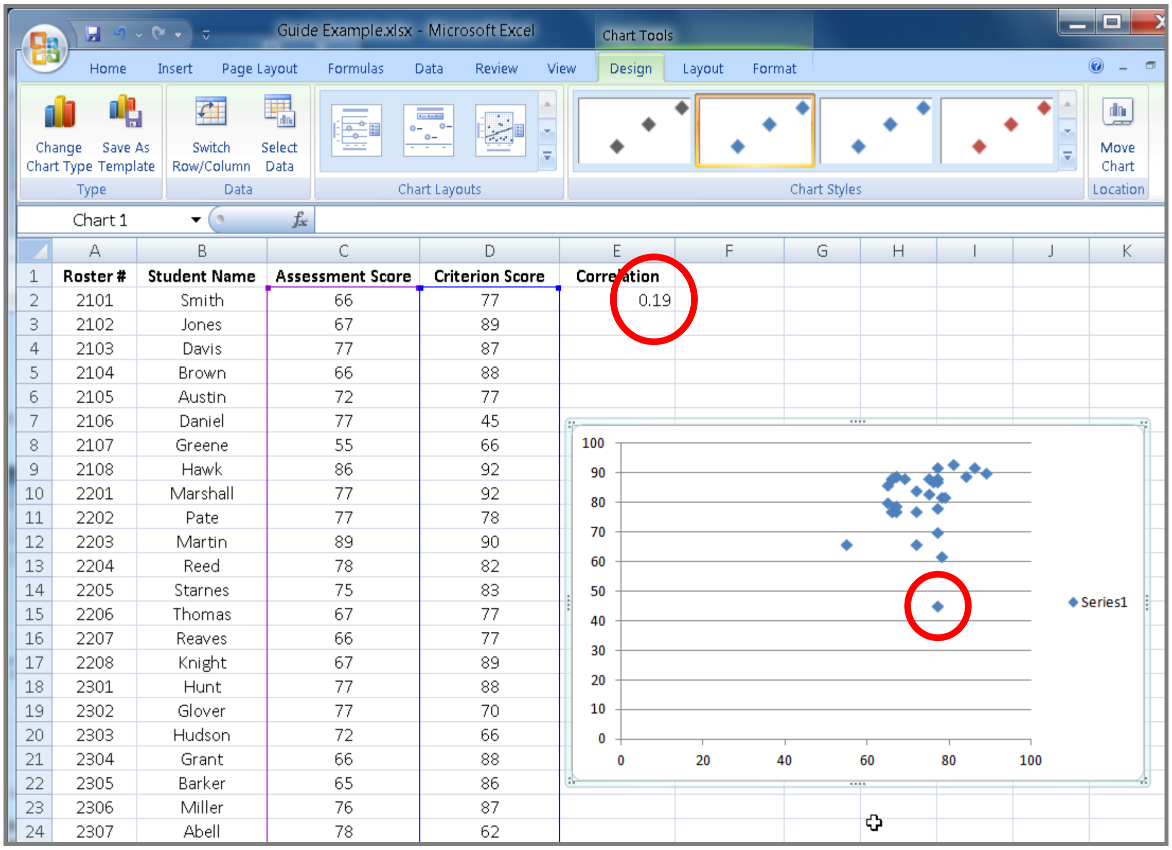


3. Move the cursor over the scatter plot option, left click with the mouse, and an option box will appear. Move the cursor down to the first option that shows data points without lines labeled “Scatter with only markers”.



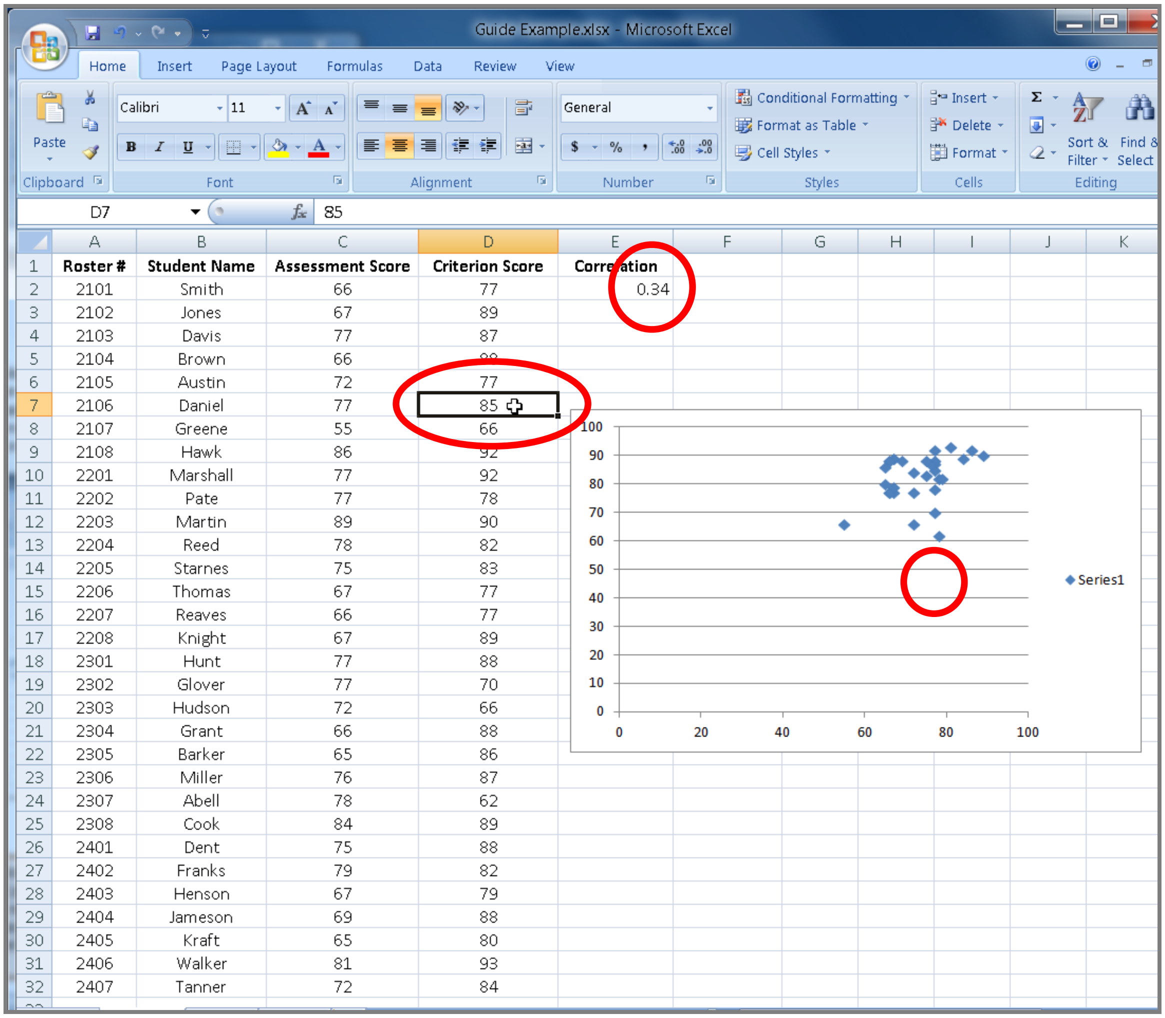
*Note: When a scatter plot is generated in Excel, the first column of data, in this case “Assessment Score”, will be the **“X axis”** and the second column of data, “Criterion Score”, will be the **“Y axis.”***

4. Left click on the “Scatter with only markers” option and a scatter plot will automatically be generated. The scale along the bottom of the chart reflects “Assessment Scores” and the scale up the left side of the chart reflects “Criterion Scores”. The scatter plot generated may be used to help identify outliers. The scatter plot below shows a possible outlier and a correlation coefficient of 0.19.



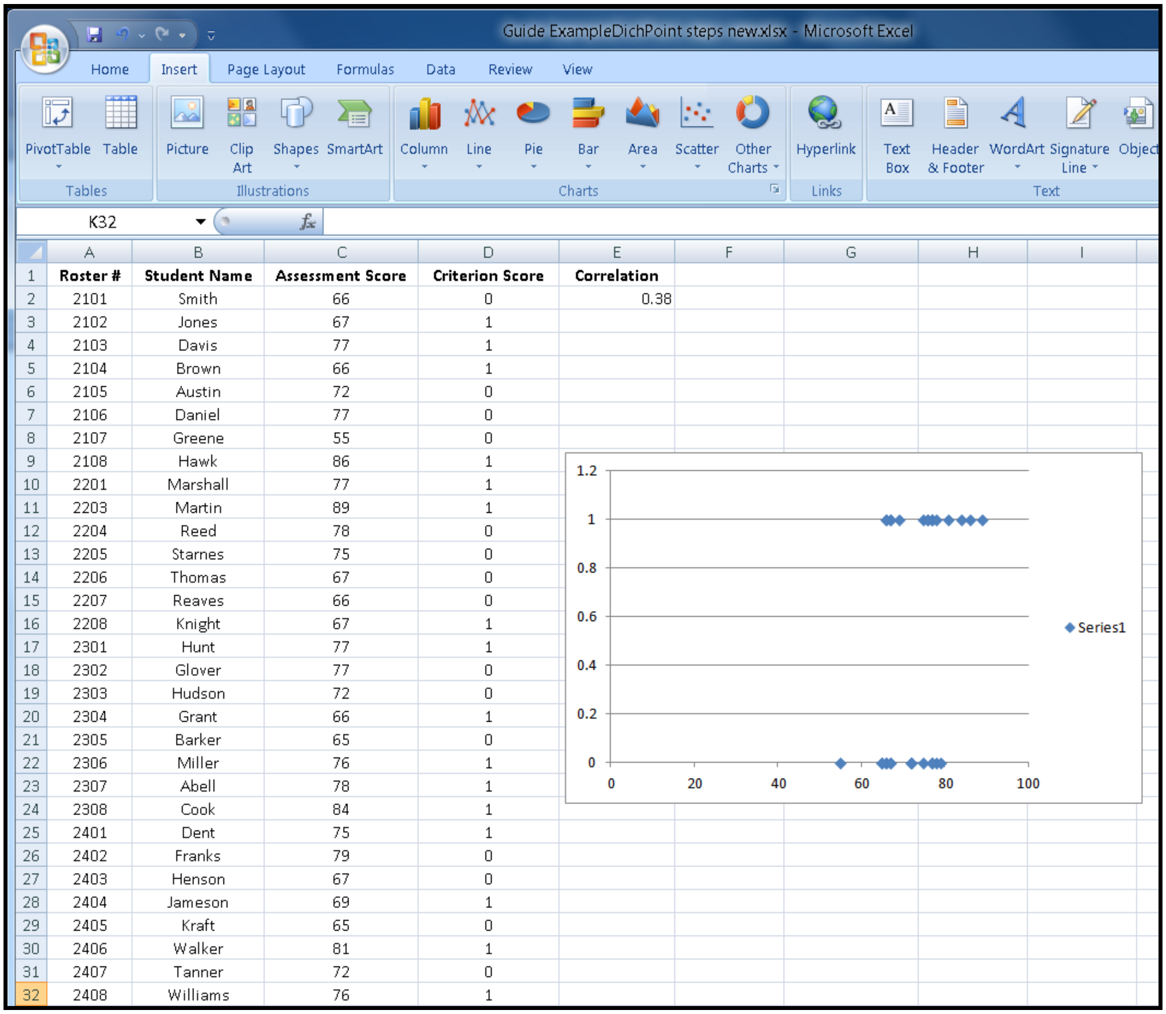
Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2101	Smith	66	77	0.19
2102	Jones	67	89	
2103	Davis	77	87	
2104	Brown	66	88	
2105	Austin	72	77	
2106	Daniel	77	45	
2107	Greene	55	66	
2108	Hawk	86	92	
2201	Marshall	77	92	
2202	Pate	77	78	
2203	Martin	89	90	
2204	Reed	78	82	
2205	Starnes	75	83	
2206	Thomas	67	77	
2207	Reaves	66	77	
2208	Knight	67	89	
2301	Hunt	77	88	
2302	Glover	77	70	
2303	Hudson	72	66	
2304	Grant	66	88	
2305	Barker	65	86	
2306	Miller	76	87	
2307	Abell	78	62	

5. If you determine that an outlier exists recheck your input data. If an error exists correct it and the correlation coefficient and scatter plot will be updated automatically. If there is sufficient justification for eliminating the outlier, simply delete all information/data on the student. Procedures for correcting input data are outlined in Appendix B of this guide. After correcting the input error, the correlation coefficient is adjusted to 0.34.



Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2101	Smith	66	77	0.34
2102	Jones	67	89	
2103	Davis	77	87	
2104	Brown	66	88	
2105	Austin	72	77	
2106	Daniel	77	85	
2107	Greene	55	66	
2108	Hawk	86	92	
2201	Marshall	77	92	
2202	Pate	77	78	
2203	Martin	89	90	
2204	Reed	78	82	
2205	Starnes	75	83	
2206	Thomas	67	77	
2207	Reaves	66	77	
2208	Knight	67	89	
2301	Hunt	77	88	
2302	Glover	77	70	
2303	Hudson	72	66	
2304	Grant	66	88	
2305	Barker	65	86	
2306	Miller	76	87	
2307	Abell	78	62	
2308	Cook	84	89	
2401	Dent	75	88	
2402	Franks	79	82	
2403	Henson	67	79	
2404	Jameson	69	88	
2405	Kraft	65	80	
2406	Walker	81	93	
2407	Tanner	72	84	

6. Follow the same procedure for creating a scatter plot that includes dichotomous data.



Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2101	Smith	66	0	0.38
2102	Jones	67	1	
2103	Davis	77	1	
2104	Brown	66	1	
2105	Austin	72	0	
2106	Daniel	77	0	
2107	Greene	55	0	
2108	Hawk	86	1	
2201	Marshall	77	1	
2203	Martin	89	1	
2204	Reed	78	0	
2205	Starnes	75	0	
2206	Thomas	67	0	
2207	Reaves	66	0	
2208	Knight	67	1	
2301	Hunt	77	1	
2302	Glover	77	0	
2303	Hudson	72	0	
2304	Grant	66	1	
2305	Barker	65	0	
2306	Miller	76	1	
2307	Abell	78	1	
2308	Cook	84	1	
2401	Dent	75	1	
2402	Franks	79	0	
2403	Henson	67	0	
2404	Jameson	69	1	
2405	Kraft	65	0	
2406	Walker	81	1	
2407	Tanner	72	0	
2408	Williams	76	1	

Chapter 4. Using and Revising Prior Knowledge Assessments

4.1 How Do I Determine Which Students Will Receive Tailored Training?

After a prior knowledge assessment has been validated, subsequent assessment results can be used to determine which students would most benefit from tailored training. A student's actual assessment score probably has less meaning in isolation than when compared to other students' scores. For example, a score of 46 on a 70 point assessment has little meaning when viewed in isolation. When compared to 30 other students with all of them scoring below 46, you quickly see a different story. The opposite could also be true. If the majority of other students scored above 46, this student could be someone destined to struggle during training without additional support.

Once you have all the scores in hand, you must determine where to make the defining cut between those likely to need assistance and/or those needing to be challenged due to their higher level of prior knowledge. There is no standard rule for establishing these cut points and deciding where to draw the line can be a challenging task. For example, an arbitrary decision of the lower 1/3 of the class may not accurately capture all the students needing tailored training. Like many other tests, these decisions often become easier only after repeated experience.

Initial prior knowledge assessment scores used during validation can identify what you should likely expect from a typical group of students. Examining the results from your validation can help determine starting cut points for students who should receive tailored training in subsequent classes. Carefully considering the data, both in raw form and on a scatter plot, can provide you an idea of where students will generally score on the assessment and how those scores generally relate to subsequent training performance.

Some factors that can impact your decision of where to establish a cut point include:

- **Past student performance on the criterion measure.** – Experience with previous student performance in the same training course on the criterion measure can help you distinguish between high and low performers. In the validation process, you will therefore be looking at scores on the prior knowledge assessment that correspond to individuals performing at these high/low levels on the criterion measure.

  Example: Results from previous courses indicate that students who tended to have little trouble advancing through training often scored above 93% on the criterion measure. They were high performers and individuals

who you think should be challenged if you were to tailor the course to address their needs. Similarly, students who struggled tended to score 65% and below on the same criterion. These students performed poorly and you believe they would have benefited from tailored training that addressed their problems. The next step is to determine cut points on the prior knowledge test which best correspond to these levels of performance on the criterion.

- **Visual analysis of results** – Are there any natural groupings or clear indications of where cut points on the prior knowledge assessment might be established by considering either the validation scatter plot or prior knowledge assessment results? Initially scatter plots of these results may provide some insights into how students are grouped on the assessment.

  Example: Visually considering the validation scatter plot revealed that students who scored above 90% on the prior knowledge assessment also seemed to perform extremely well on the criterion measure.

- **Strength of the validation correlation coefficient** – Does the strength of the correlation coefficient potentially have any effect on deciding where to establish the cut point? The stronger the relationship between assessment results and demonstrated performance, the more confident one can be in predicting how students will perform. Establishment of cut points in weaker relationships means that some students selected for tailoring may not need it and/or some students not chosen may have benefited more had they received it.

  Example: The validation results showed a correlation coefficient of 0.33 between the assessment scores and the criterion. While this correlation coefficient can be used to help establish cut points, it will likely ensure that some lower performers on the criterion may be included with higher scorers. The instructor decides to err on the side of caution and provides more students with additional assistance. He also plans to observe students during training for signs of those that could be removed or added to that training.

- **Prior experience with a Prior Knowledge Assessment** – Has the prior knowledge assessment been used in previous training? Previous use of prior knowledge assessments is one of the best sources of information for establishing cut points. An examination of student assessment results coupled with the cut point used for that training and the associated student subsequent performance results can help determine whether the cut point established should be adjusted or not.

  Example: Prior experience in using the assessment shows that generally students who score below 75% on the assessment could benefit from additional assistance.

- **Resources available** – Do resources potentially have an effect on how many students will receive tailoring? Resource impacts may include a limitation of equipment and/or facilities used in tailoring, a limitation of instructor personnel needed to administer tailoring, and/or a limitation of the time available to conduct tailoring.

  Example: Available resources may limit tailoring to only the bottom or top 10 students in the class.

Consider the scatter plot examples in Figures 11, 12, and 13 generated from validation results.

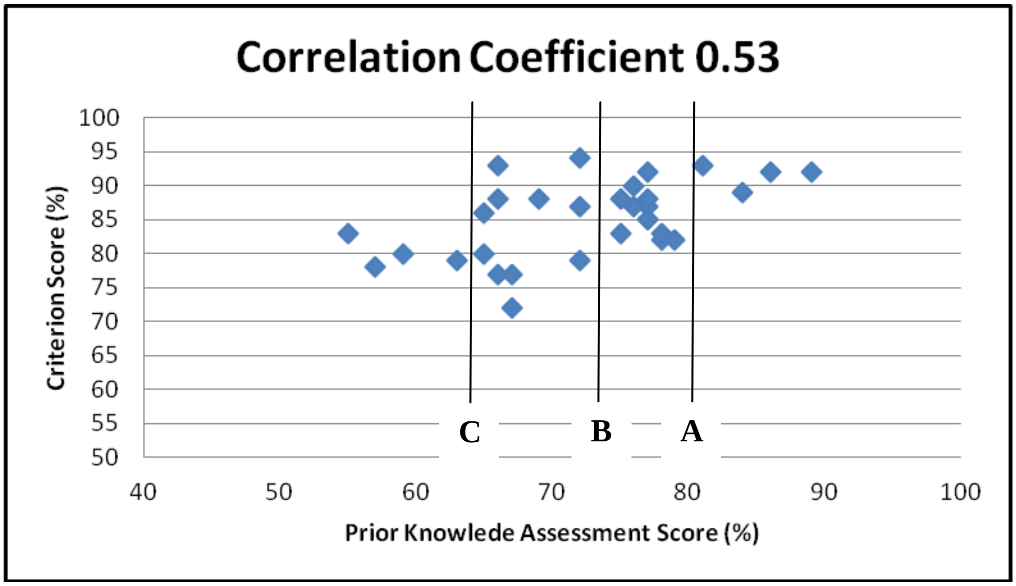


Figure 11. Relationship of student scores (0.53 correlation coefficient).

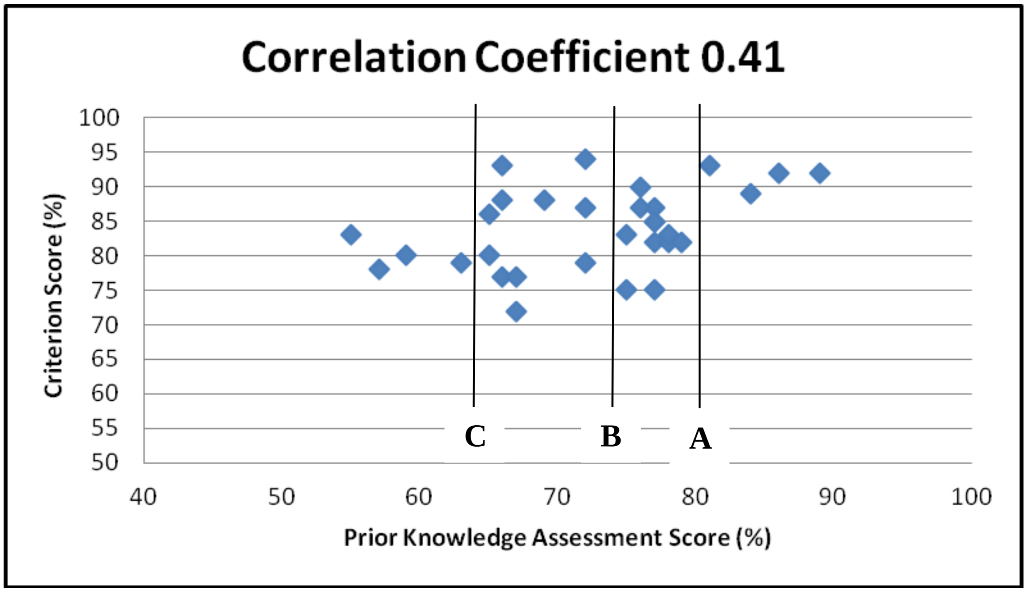


Figure 12. Relationship of student scores (0.41 correlation coefficient).

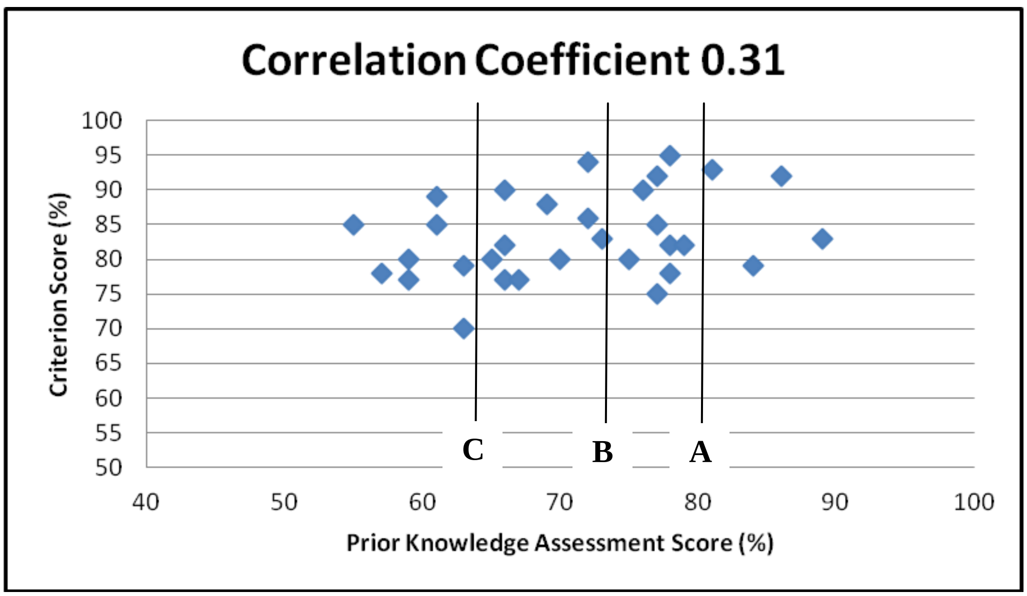


Figure 13. Relationship of student scores (0.31 correlation coefficient).

In the figures, assume that resources are not a limitation and that the instructor has no prior experience with the prior knowledge assessment.

Identifying high performers - those who need to be challenged. Assume you know that high performers on the criterion test score at least 90%. Consider the vertical line at point "A". With stronger correlation coefficients as in Figures 11 and 12 there is a natural grouping of four students who scored above 80% on the prior knowledge assessment and also performed well in the course as evidenced by a criterion score of

88% or above. Although you assume that 90% and above is the desired level on the criterion, only one of the 4 students scored below 90% with this individual still having a relatively high score on the criterion (88%). Assuming similar results in the future, an 80% cut point on the prior knowledge test seems appropriate. Note, however, that there were other individuals who scored 90% and above but had prior knowledge scores below 80%. Thus the prior knowledge assessment did not uniquely identify all the high performers on the criterion. With the weaker correlation in Figure 13, natural groupings of students are not as apparent as in Figures 11 and 12. In Figure 13 with a weaker correlation coefficient, the grouping is not as tight as evidenced by the wider dispersion of criterion scores, with two students who scored above 80% on the prior knowledge assessment, but below 90% on the criterion. If you used the 80% prior knowledge cut point based on these data, you might find that challenging some of these students is not successful and they should receive the "regular" instruction.

Now consider the vertical line "B" of 73% on the prior knowledge test. In all three figures, this cut point is not acceptable for identifying high performers – those who need to be challenged. In each case the spread of criterion scores has increased and includes many individuals who did not score above 90% on the criterion.

Identifying low performers – those who need assistance. Now assume that a criterion score of below 80% is associated with low performers. With the stronger correlations shown in Figures 11 and 12 you will note that there are a number of students to the left of line "B" who did not score 80% or better on the criterion as well as a number of students who did. However, you will notice at vertical line "C" that three out of the four students to the left of line "C" scored below 80% on the criterion with the fourth fairly close at 83%. You will also notice that all four of these students scored below 63% on the prior knowledge assessment. Making the assumption that this association holds true in the future, using 63% as a prior knowledge score cut point for students requiring tailoring seems reasonable. Therefore, line "C" would be a better cut point than line "B". In the weaker correlation example shown in Figure 13, the grouping of the scores to the left of line "C" was more widely dispersed as students' prior knowledge assessment scores ranged from some near 90% to others near 70%. Again, a lower correlation makes it more challenging to determine cut points.

These examples simply give an idea of how you may use the validation scatter plot data to help visualize groupings of students and help establish cut points. Sorting of prior knowledge assessment results in ascending or descending order can also help visualize groupings of students and aid in the establishment of cut points. Sorting of assessment results can be accomplished easily in Excel. An example of sorting of data in Excel is provided in Appendix B.

You should remember that the relationship between the prior knowledge measured on the assessment and actual student performance in training will not be perfect. In essence this means that due to the lack of a perfect association, some students assumed to excel in the course may not and some students assumed to have trouble in the course may excel. This in turn may exclude some students from tailored training

who need it and include some students who do not depending on where you ultimately decide to establish your cut points for students to participate in tailored training.

4.2 How Do I Administer a Prior Knowledge Assessment?

Administration of a prior knowledge assessment is accomplished in the same manner as any other test in a classroom. As discussed previously, the assessment should be given within the first few days of arriving for training. Whether the assessment is administered for the first time for validation or subsequently for identifying students for tailored training makes no difference in administration procedures.

Administration Procedures

During administration for validation, assessments should be distributed to all students who will potentially be included in the validation process. Students should be given an adequate amount of time to complete the assessment. Remember, the intent behind the prior knowledge assessment is to determine the students' extent of prior knowledge, not their reading speed or comprehension. Therefore, be sure to consider the reading and English language capability of the students when establishing the time allowed for completing the assessment.

In order to obtain the most valuable data, students should be encouraged to perform to their best ability on the assessment. Students who feel the assessment will not impact their grade or progress in training may be inclined not to answer questions to their best ability. Ensure the attitude displayed to students during assessment administration encourages their best performance.

Collecting the Results

If being used for validation, collect assessment results and secure them for future use. At the appropriate time, you will also need to collect criterion results for validation purposes. Validated assessments used for tailoring training are scored immediately after administration to determine which students should be targeted for tailored training.

After collecting results from an assessment to be used for tailoring, you should use whatever conditions were set to identify the students for tailored training. Conditions may either be based on a set number of individuals, a set assessment score, a combination of both, or others you determine. For example, you may want to target those students scoring below a certain assessment score but may only be able to accommodate 10 students for tailoring. This could mean you have less than ten students identified for tailoring if the class scored well or you may have to select the 10 lowest scores if more than 10 students scored below your target cutoff score. Once targeted students have been identified, you have accomplished the purpose behind the prior knowledge assessment.

4.3 What if the Assessment was Not Valid?

After developing a prior knowledge assessment and performing all steps for validation, you will have calculated a correlation coefficient. As discussed previously, a validated assessment will generally have a correlation coefficient greater than 0.3. Assessments that did not validate have correlation coefficients less than 0.3. Since use of these assessments can lead to misleading conclusions about which students should be targeted for tailoring, you would not be able to use an assessment with a correlation coefficient of less than 0.3 in its current form. All may not be lost however. Your assessment may still be of use. An analysis of the correlation coefficient will help you determine if modifying the assessment would likely improve the likelihood of validation.

Correlation Coefficient Analysis

The first thing you should consider for an assessment that did not validate is how close it came to validating. One would agree that the difference between a correlation coefficient of 0.29 and 0.3 is very slight while the difference between correlation coefficients of 0.1 and 0.3 is much greater. While not strong enough to support using the assessment to predict later performance, correlation coefficients that approached 0.3 can indicate that some relationship exists and modifications may make it a useful assessment. On the other hand, weaker correlation coefficients or correlation coefficients that are closer to 0.0 indicate the assessment will either require major modifications or may not be useful at all. Looking at the main causes for an assessment not validating will help determine if modifying your existing prior knowledge assessment, or criterion measure, is more prudent than developing a new assessment.

Potential Causes for Not Validating

There are a variety of possibilities for why prior knowledge assessments fail validation, all of which cannot be covered here. However, there are a few major factors to consider that may aid in understanding the cause of the assessment not validating. Reviewing these factors can assist in revising or redesigning your prior knowledge assessment to obtain a more predictive tool. Major factors include:

- **Areas Assessed** - The prior knowledge areas assessed may have little or no bearing on actual student performance.
- **Questions Used** - The questions developed may not properly sample the level of prior knowledge in the areas assessed.
- **Criterion Used** -The criterion used may include measurements of student performance outside those potentially impacted by the presence of prior knowledge.
- **Timing of Criterion Measurement** - The measurement used to develop a criterion score was taken at the wrong point in training.

Areas Assessed

For correlation coefficients that indicate weak relationships, you and the instructors should review your basic assumptions about the relationship of prior knowledge to

student performance. Prior to developing the assessment, you made an assumption that having prior knowledge in certain knowledge areas would assist students in their performance throughout training in that course or block of instruction. It is worth revisiting that assumption to scrutinize whether or not you still believe it is valid. It may be that prior knowledge in those areas has little to do with whether or not the student can or will perform well in training. If you and the instructors determine that to be the case, then a reanalysis of what prior knowledge areas may potentially impact performance should be accomplished. There may be knowledge areas that were not assessed that may be better related to performance outcomes. It may also hold true that prior knowledge in any particular area may not help predict student performance for that specific training.

If you and the instructors determine that other knowledge areas may better predict student performance, a new assessment will have to be developed and the validation process performed once again. If you and the instructors still believe the areas assessed impact actual performance, you should look at additional causes for the lack of validation.

Questions Used

You and the instructors may look at the assessment questions used to measure the level of prior knowledge. Remember, the idea behind the questions is to provide a sample of individual student knowledge that indicates how much that student knows about some particular subject or knowledge area. Review the questions to be sure they cover a good sampling of facts or topics in each particular knowledge area.

Review the section in this guide on question development to determine if the questions follow the guidelines described. Make sure that question difficulty and question cognitive levels are geared toward identifying the students you want. In evaluating each question, consider the following general points which are described in further detail in Chapter 2 and are generally applicable to all question formats.

- Ask questions involving significant or major content and avoid trivial information.
- Make sure the question is clear.
- Include directions that clearly state the basis for answering the question.
- Avoid long, complex questions while still ensuring the question is fully stated.
- Ensure questions are stated so there is only one interpretation of the meaning and only one correct response for each question.
- Avoid trick questions.
- Avoid negatively stated questions.
- Avoid absolute encompassing words such as “always”, “all”, or “never”.
- Consider the use of diagrams, pictures, charts, tables and figures for application of principles and concepts.

Each question should be evaluated to ensure it is asking for appropriate knowledge in an appropriate manner. It may also be useful to analyze student responses for each question to aid in identifying possible problems with individual questions. For example, if most students answered a particular question incorrectly, or gave similar incorrect responses to a question, you may look at their responses to determine if there is an issue with the question itself. It may be that the question itself or the question directions were not clear or were misleading.

Although beyond the scope of the discussion within this guide, there are more options for evaluating a prior knowledge assessment for those looking for a further analysis. Of note, a test item analysis may also be conducted on either the assessment, the test from which a criterion score was obtained, or both. A test item analysis provides statistics on overall test performance and individual test questions. It helps in identifying questions that might be poor discriminators of student performance and can be used to improve questions for future test administrations. An item analysis includes two main statistics that help analyze test questions. The first looks at question difficulty and shows the percentage of students who selected the correct response. The second involves item effectiveness/discrimination and indicates how well the question separates the students who know the material well from those who did not. For a further understanding of these concepts and some assistance on setting up the calculations in Excel visit the following websites:
Penn State, Schreyer Institute for Teaching Excellence, Improve Multiple Choice Test Using Item Analysis found at: http://www.schreyerinstitute.psu.edu/Tools/ItemAnalysis/ and Selection Matters Blog found at: http://selectionmatters.jmadigan.net/?p=124

Criterion Used

After reviewing the assessment for subject content and question presentation you and the instructors may also look outside of the assessment itself for other potential causes for not validating. Remember that the assessment score is only one of two measures used in validation with the other being the criterion that measures actual performance. You and the instructors should evaluate the criterion used in validation to ensure it measures what was intended. Chapter 3, paragraph 3.3 discusses the development of the criterion measure used for validation. In that discussion, we indicated that course performance measurements from course ratings, scores, or rankings need to be those that are potentially impacted by the presence of prior knowledge, or lack thereof. They should not however, include ratings based on performance not relevant or potentially not relevant to the presence of the prior knowledge areas you identified.

Review of the criterion measure may reveal inadvertent inclusions of irrelevant measurements. In this instance, it still may be possible to use the criterion by removing any irrelevant measurements. In such cases, after obtaining new criterion scores that measure only applicable student performance, you may once again attempt to validate your assessment using the original assessment scores and the new criterion scores. Another potential issue with the criterion may be that student scores are not dispersed well enough to make a correlation. For example, if nearly all student criterion measurements were similar, then the dispersion between the scores would not have a

large enough spread to correlate with assessment scores. In either case you should check to ensure the criterion is measuring what you intended.

Timing of Criterion Measurement

Once you are comfortable that your criterion is measuring what you intended, you may also consider the timing of when those scores were obtained. How and when the criterion measurements were taken may potentially impact your validation results. This can be true for any criterion measurements, but is especially true for dichotomous measurements such as Go/No-Go scoring. Consider a case where criterion scores are obtained for 30 students at the end of training. Suppose all 30 students received an overall “Go” for the course. Comparing prior knowledge assessment scores to all “Go” scores tells you nothing about which students had more or less difficulty with the training content. Although all students received the same rating at the end of training, some may have struggled much more than others to obtain that rating. In this case, it would be better to obtain criterion scores for students earlier during training to help distinguish those who had more difficulty with the content from those who found it easier. Review the figures in paragraph 3.3 of this guide regarding the timing of criterion measures to see if they were taken at the most appropriate time. As discussed in this section, you should also consider alternatives to using dichotomous measurements that could better distinguish individual student performance.

Recording continuous numerical or nondichotomous criterion measurements late in training can also affect validation results. Take, for example, an assessment looking to identify students who could benefit from additional training in prior knowledge areas early in a course. The more exposure students have to other students and training related content, the more knowledge they gain even if not specifically taught in the course. In other words, the more association students have with information on knowledge areas covered in the assessment, the more likely they are to use that knowledge in actual performance related criterion measures. In an overall training sense, this is not a problem as the intent is for all students to perform well in training. However, the intent for prior knowledge assessment validation is to determine if a relationship of prior knowledge to later performance exists. Criterion scores obtained late in training may obscure the fact that some students initially struggled with training due to the lack of prior knowledge. In this case, it would be beneficial to obtain criterion measurements at some earlier point in training rather than waiting until the end as shown in Figure 1, Course X, in Chapter 3.

4.4 When Do I Need To Revalidate the Assessment?

Prior knowledge assessments are generally developed for a specific block of instruction or course. Once developed and validated, the prior knowledge assessment should be useful for subsequent training for the specific course for which it was designed. Generally, the assessment will remain useful when administered to similar groups of students attending that particular training course. Remember that the assessment was validated by establishing that a relationship exists between students’ level of prior

knowledge in certain knowledge areas and their performance in training. However, changes made to the training content or conditions could affect that relationship. If changes are made to the training content in which a prior knowledge assessment is used, you should consider whether those changes have altered the prior knowledge areas deemed to be useful for that training.

Changes that alter or remove the basis for which the prior knowledge areas were chosen may render the assessment not valid for use. Any changes to course content should be evaluated to determine whether or not those changes effect what prior knowledge was sampled in the assessment. If the basis for which those prior knowledge areas was removed as a result of the changes then new knowledge areas will need to be identified, a new assessment designed, and validation procedures performed once again.

If you and the instructors determine that the changes to course content had little to no effect on the prior knowledge areas chosen, then the assessment can continue to be used for making tailored training decisions. To double check the validity of the assessment you can collect criterion measurements, in the same manner as done in assessment validation, and compute a new correlation coefficient. Revalidation of the assessment comes from obtaining a new correlation coefficient of 0.3 or above.

4.5 What Else Can the Data Tell Me?

Using prior knowledge assessments to identify students for tailored training can help instructors enhance students' learning experience, facilitate transfer of knowledge, and increase student performance in the classroom. Along with the implementation of tailored training, other factors can also affect their learning experience. Consider how the following factors may affect student performance in the classroom.

- **Different Instructors** – Instructors have their own unique way of delivering content during training. Given two identical courses with identical content, two instructors will have their own instructional strategies and may even emphasize different aspects of training content. Information may potentially be received differently by a particular student depending on which instructor delivered the training and how it was delivered. If a new or different instructor is introduced into the classroom, it can have an effect on student performance even without the benefit of tailored training.
- **Different Instructional Strategies** – Instructors often adjust their training strategies as they become more familiar with instructing, instructional techniques, training material, and course content. As instructors evolve, they may either purposely or inadvertently alter their delivery or delivery techniques to accommodate how students respond best. Even though content may not have changed, these changes by the instructor may also dramatically affect student performance.

- **New/Different Equipment or Training Aids** – As with different instructional strategies, introducing new or different equipment or training aids can alter what students learn and how students respond to training.

Regardless of how a student's learning experience is affected, whether from tailored training or one of the additional factors above, the intent is to increase student performance. To check improvements in student performance, you can compare student performance results from validation efforts to performance results after implementation of tailored training. In order to accomplish this, you should measure your criterion in a class that received tailored training in the same manner it was measured for validation. The data can be displayed via a scatter plot using methods similar to those used in validation. By visually comparing the scatter plot used in your original validation to the new scatter plot generated, you should expect some change in performance measurements. Visualization of this data will simply help you track whether tailoring and other changes improve student performance and should be used in subsequent training in which the prior knowledge assessment is used.

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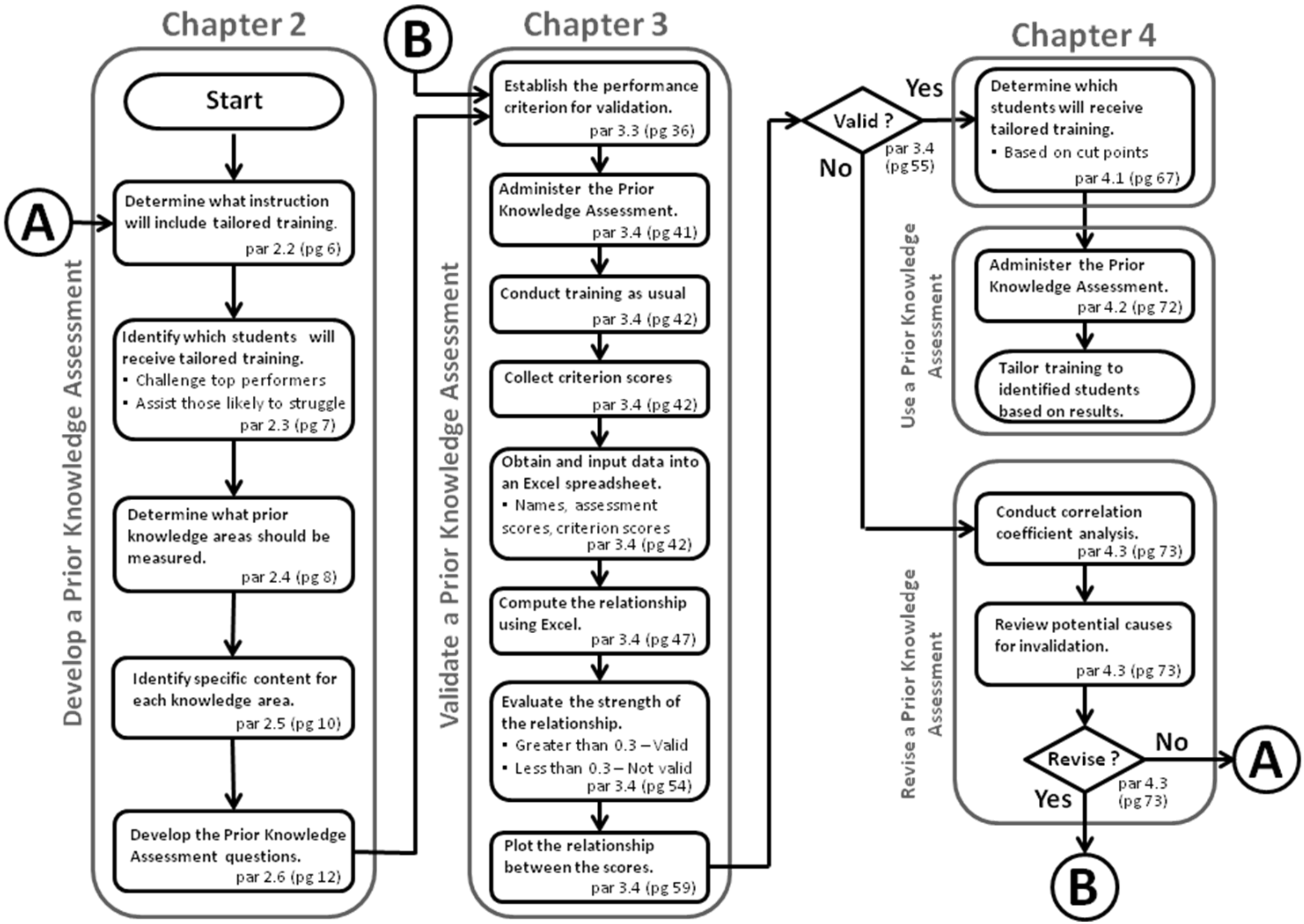
Appendix A

Quick Reference Flowchart

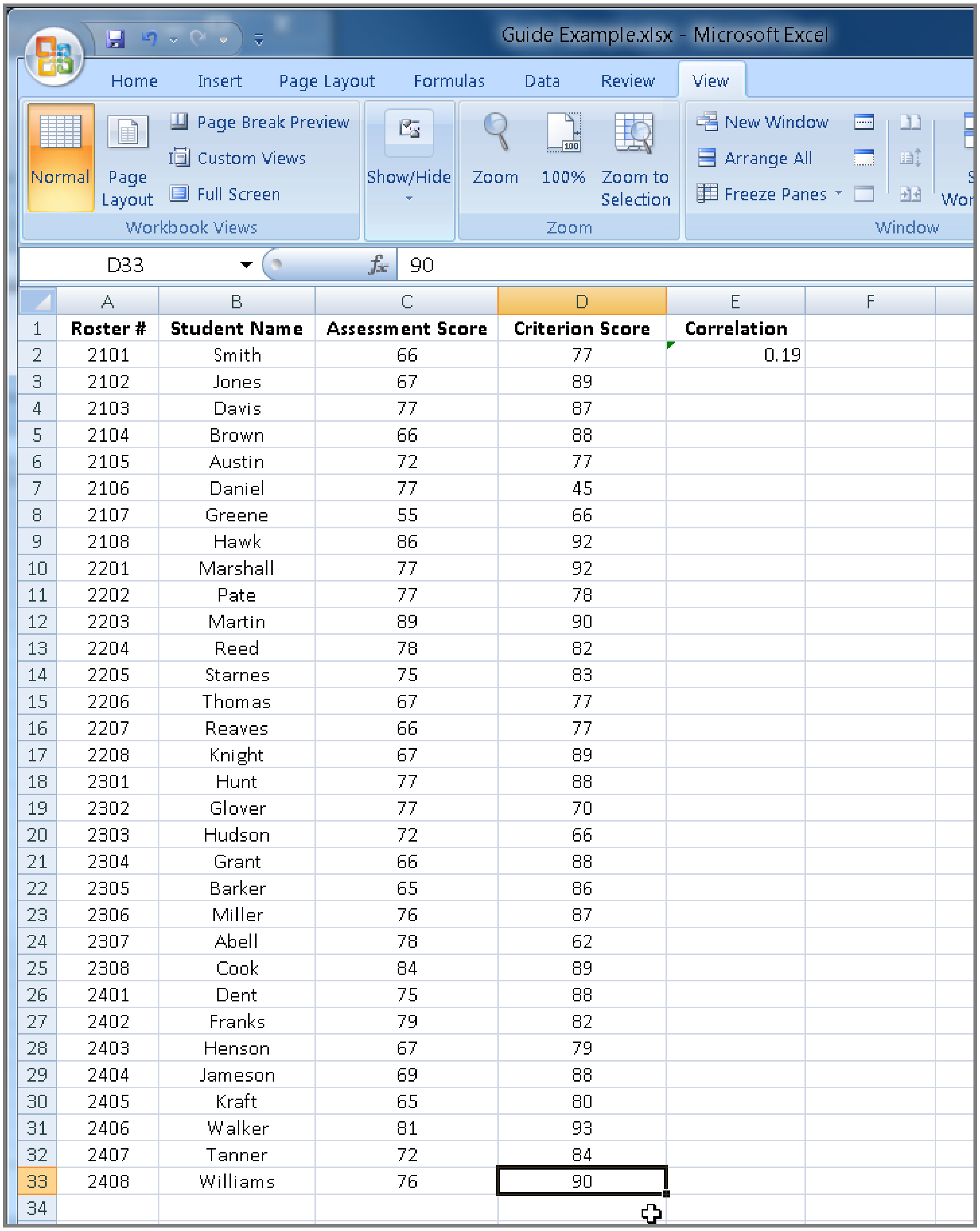

Chapter 2
Chapter 3
Chapter 4
Start
A
B
Develop a Prior Knowledge Assessment
Determine what instruction will include tailored training. par 2.2 (pg 6)
Identify which students will receive tailored training.
▪ Challenge top performers
▪ Assist those likely to struggle
par 2.3 (pg 7)
Determine what prior knowledge areas should be measured. par 2.4 (pg 8)
Identify specific content for each knowledge area. par 2.5 (pg 10)
Develop the Prior Knowledge Assessment questions. par 2.6 (pg 12)
Validate a Prior Knowledge Assessment
Establish the performance criterion for validation. par 3.3 (pg 36)
Administer the Prior Knowledge Assessment. par 3.4 (pg 41)
Conduct training as usual par 3.4 (pg 42)
Collect criterion scores par 3.4 (pg 42)
Obtain and input data into an Excel spreadsheet.
▪ Names, assessment scores, criterion scores
par 3.4 (pg 42)
Compute the relationship using Excel. par 3.4 (pg 47)
Evaluate the strength of the relationship.
▪ Greater than 0.3 – Valid
▪ Less than 0.3 – Not valid
par 3.4 (pg 54)
Plot the relationship between the scores. par 3.4 (pg 59)
Valid ?
par 3.4 (pg 55)
Yes
No
Use a Prior Knowledge Assessment
Determine which students will receive tailored training.
▪ Based on cut points
par 4.1 (pg 67)
Administer the Prior Knowledge Assessment. par 4.2 (pg 72)
Tailor training to identified students based on results.
Revise a Prior Knowledge Assessment
Conduct correlation coefficient analysis. par 4.3 (pg 73)
Review potential causes for invalidation. par 4.3 (pg 73)
Revise ?
par 4.3 (pg 73)
No
Yes
A
B

Appendix B

Editing Input Data in Excel

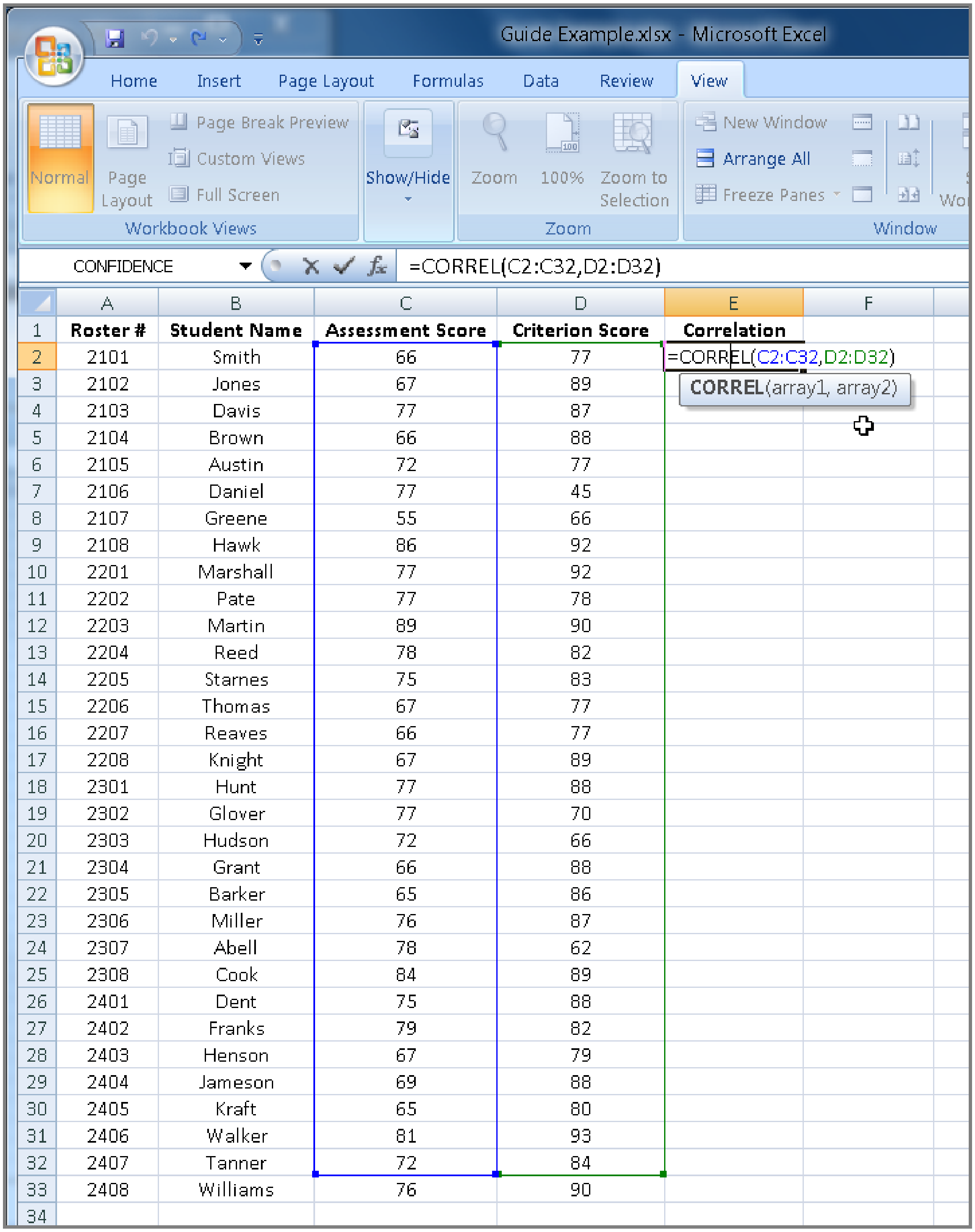
Adding Data

1. After the function appears to be working correctly you may increase the sample size (number of students) if needed. If you need to add a student to the existing list simply type the name and scores at the end of the existing list. The examples below show continuous numerical measurement data. The procedures are the same for dichotomous data.



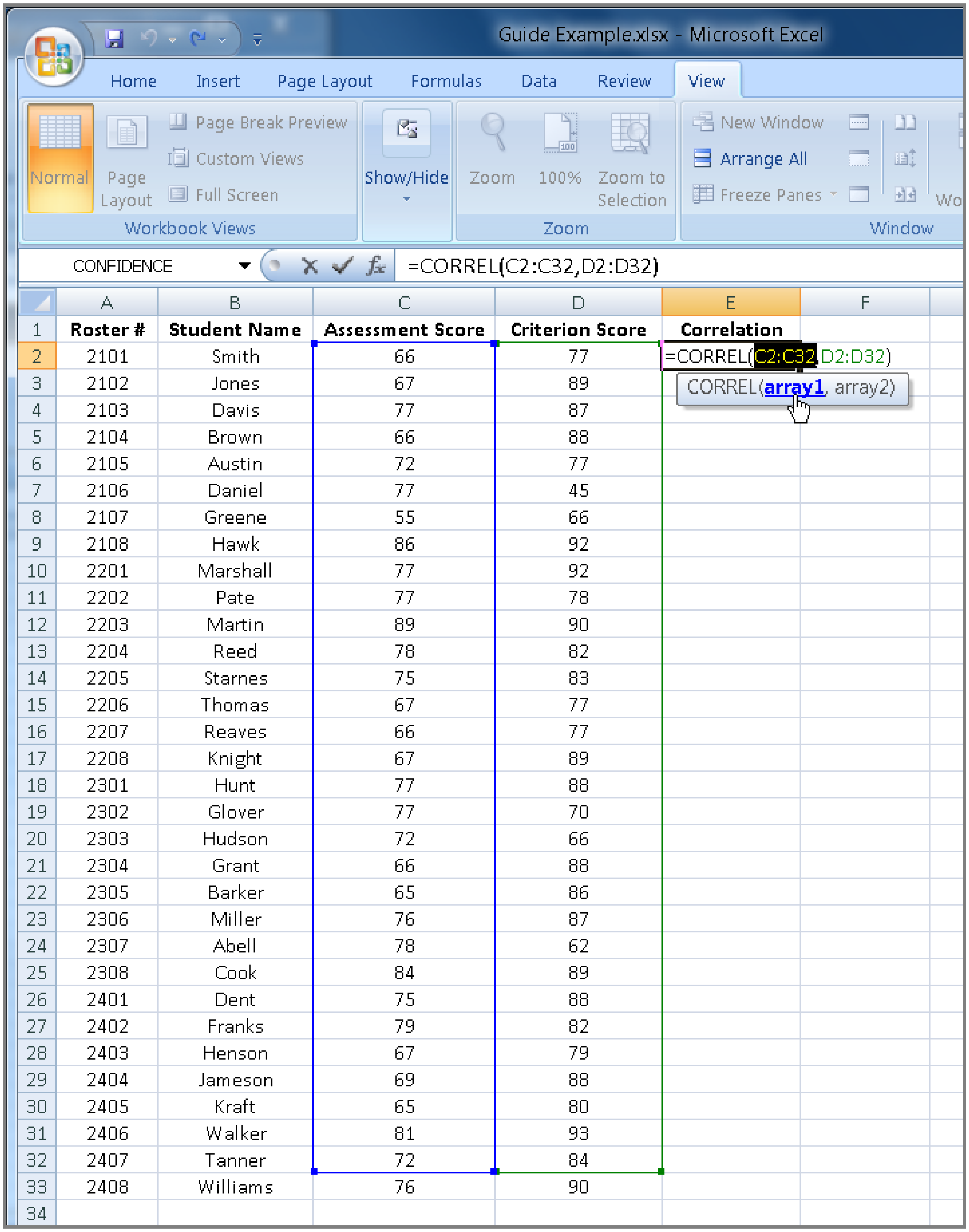
	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	0.19	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

2. “**Double click”** with the left mouse button in the cell where you entered the correlation function and you will see the function in the cell and the two boxes appear that encompass your original input.



	A	B	C	D	E	F
1	**Roster #**	**Student Name**	**Assessment Score**	**Criterion Score**	**Correlation**	
2	2101	Smith	66	77	=CORREL(C2:C32,D2:D32)	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

3. Take the cursor and point to “array 1” in the function and click the left mouse button. Array 1 will highlight in bold.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	=CORREL(C2:C32,D2:D32)	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
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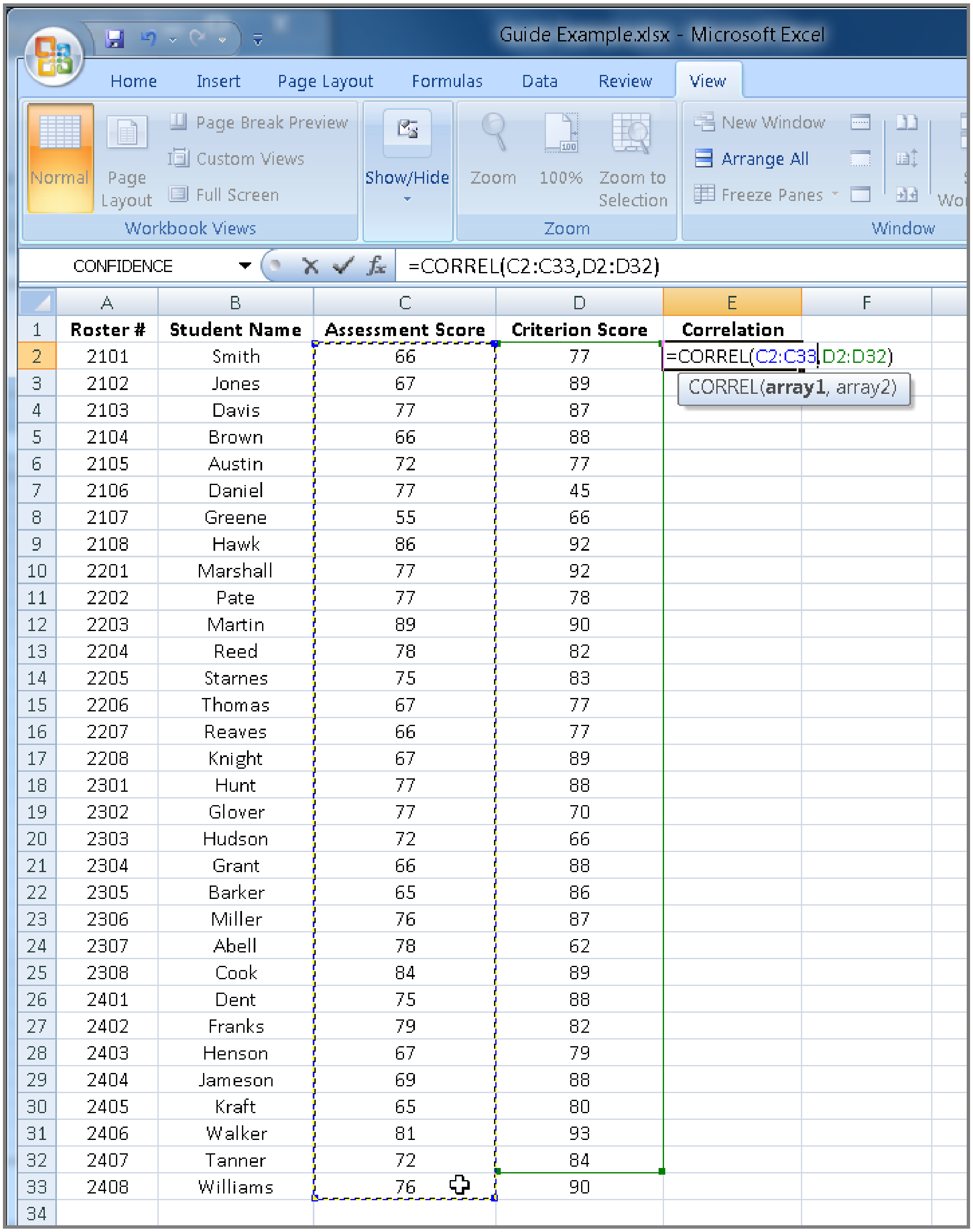
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

4. As before, take the cursor and position it over the first number in the Assessment Score column, cell “C2”, click the left mouse button and while holding it down drag to the last number in that column, to include the new entry, and release the left mouse button.



	Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2	2101	Smith	66	77	=CORREL(C2:C33,D2:D32)
3	2102	Jones	67	89	
4	2103	Davis	77	87	
5	2104	Brown	66	88	
6	2105	Austin	72	77	
7	2106	Daniel	77	45	
8	2107	Greene	55	66	
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20	2303	Hudson	72	66	
21	2304	Grant	66	88	
22	2305	Barker	65	86	
23	2306	Miller	76	87	
24	2307	Abell	78	62	
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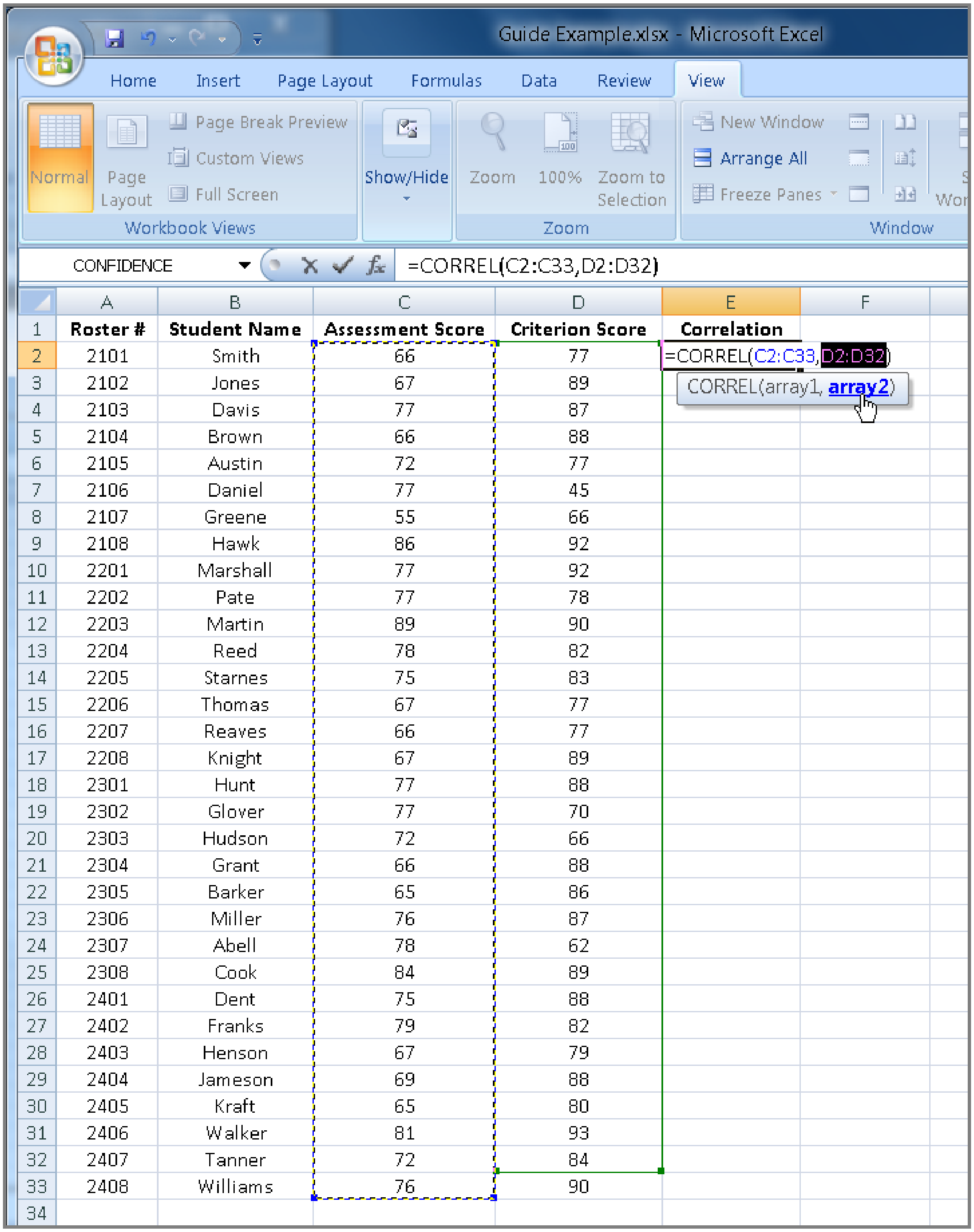
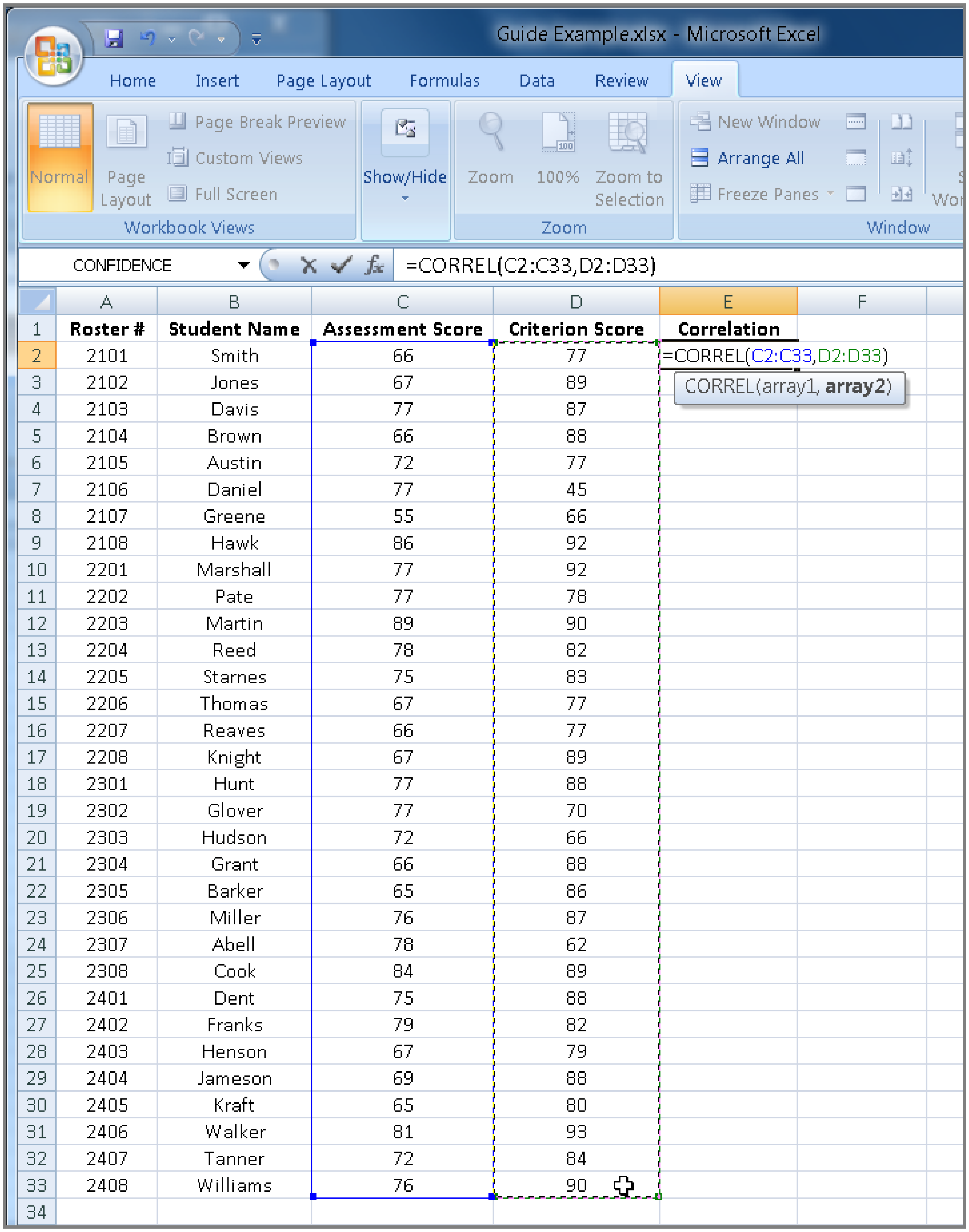
27	2402	Franks	79	82	
28	2403	Henson	67	79	
29	2404	Jameson	69	88	
30	2405	Kraft	65	80	
31	2406	Walker	81	93	
32	2407	Tanner	72	84	
33	2408	Williams	76	90	

5. Take the cursor and point to “array 2” in the function and click the left mouse button. Array 2 will highlight in bold.



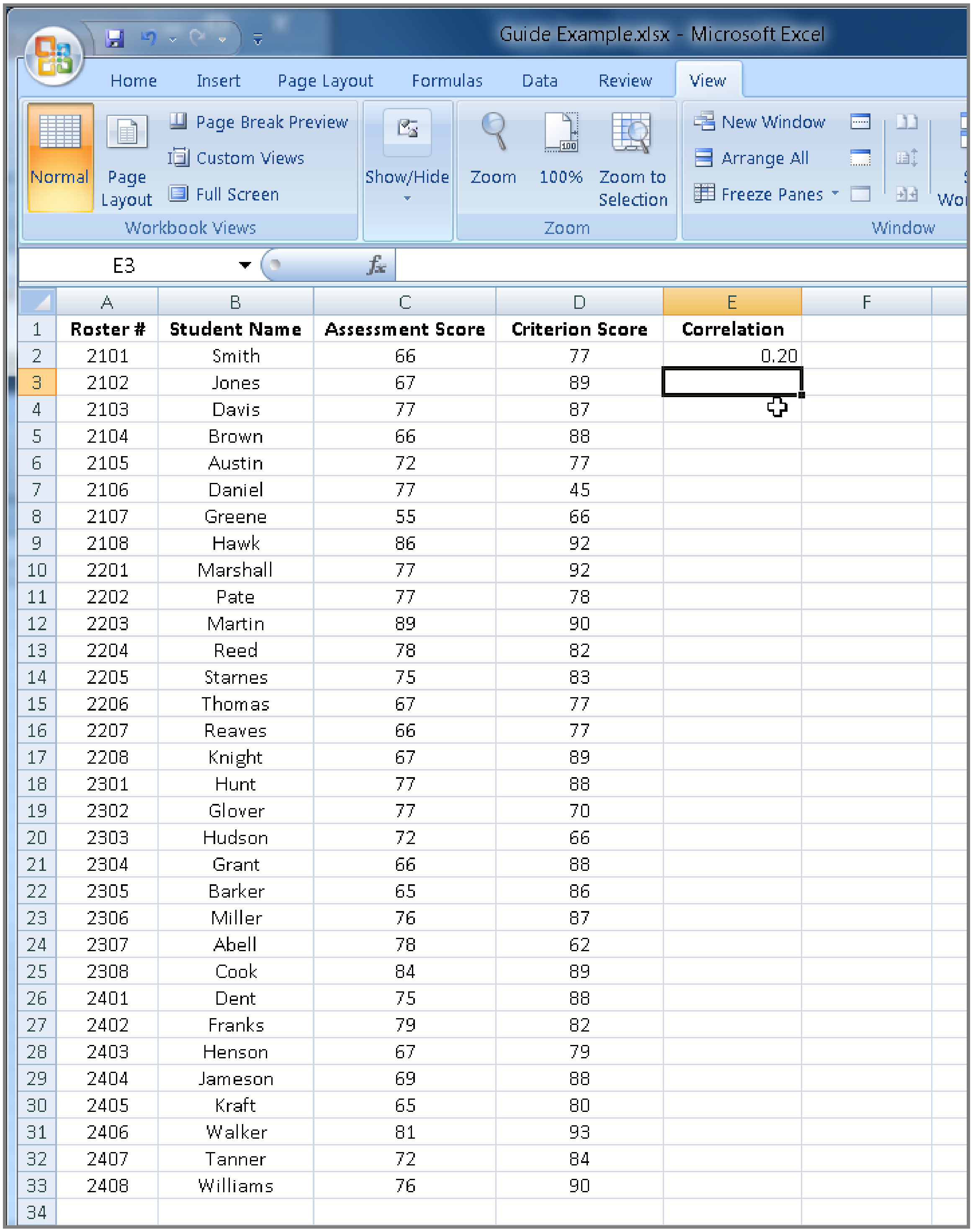
	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	=CORREL(C2:C33,D2:D32)	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

6. Similarly, take the cursor and position it over the first number in the Criterion Score column, cell "D2", click the left mouse button and while holding it down drag to the last number in that column, to include the new entry, and release the left mouse button.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	=CORREL(C2:C33,D2:D33)	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

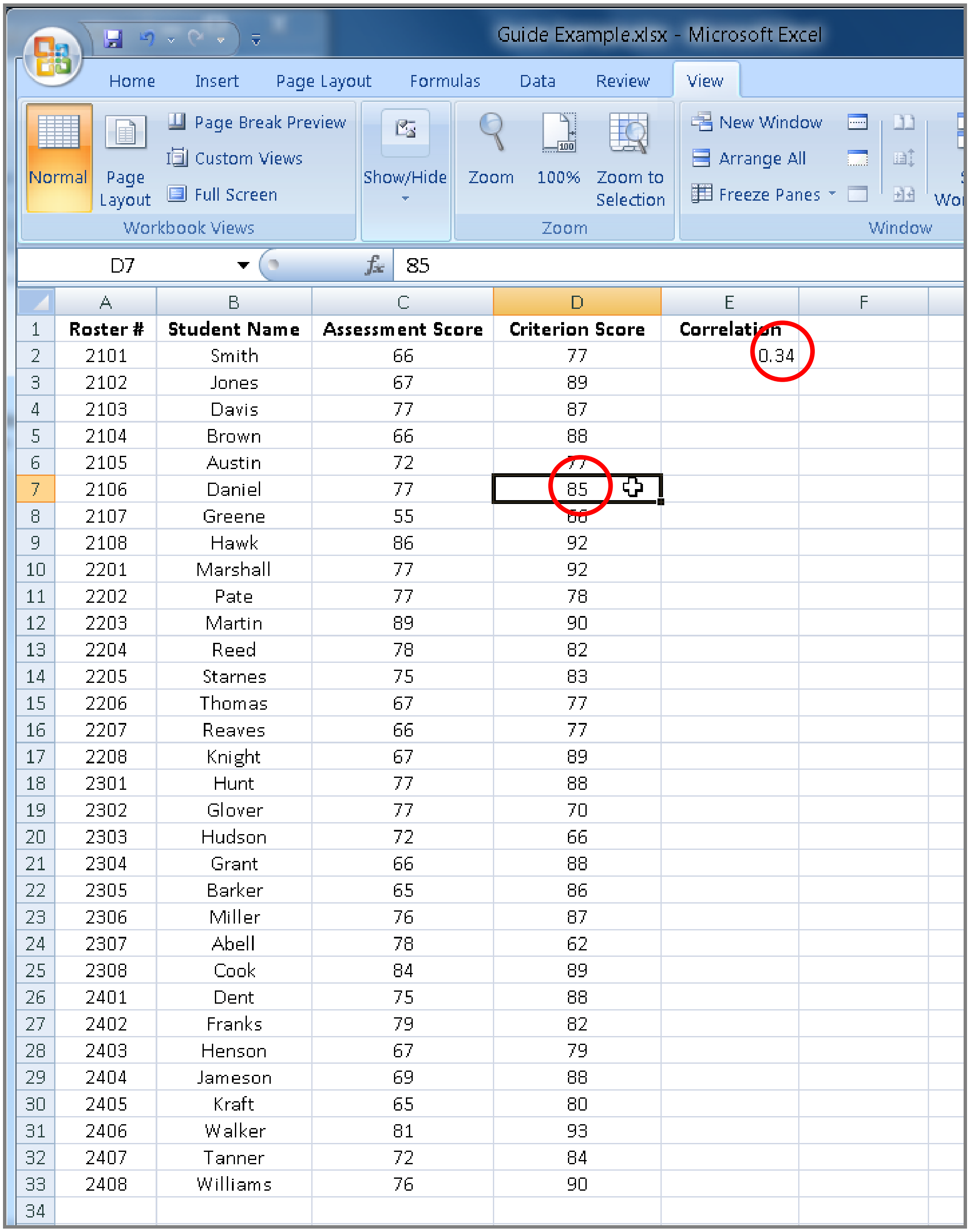
7. You will notice that as you increase the size of the boxes the corresponding cell positions automatically change in your formula. Once both boxes have been resized, hit the “Enter” key and your new value including the new entry will be calculated.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	0.20	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	45		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

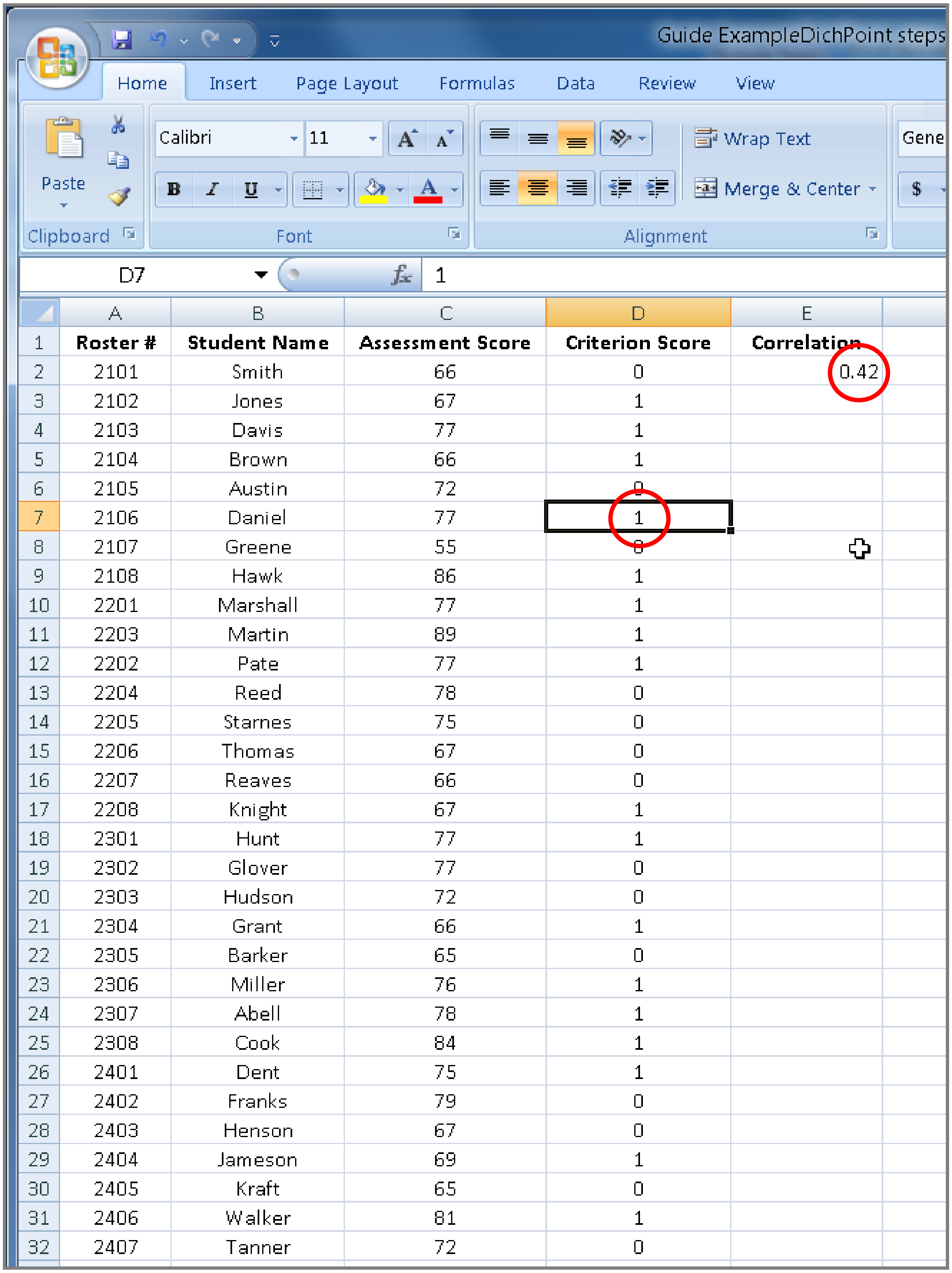
Changing Input Values

1. If you found that you made an input error, you may change any of the data you entered, hit the “Enter” key, and it will automatically update the correlation coefficient. The examples below show continuous numerical measurement data. The procedures are the same for dichotomous data.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	0.34	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	85		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2202	Pate	77	78		
12	2203	Martin	89	90		
13	2204	Reed	78	82		
14	2205	Starnes	75	83		
15	2206	Thomas	67	77		
16	2207	Reaves	66	77		
17	2208	Knight	67	89		
18	2301	Hunt	77	88		
19	2302	Glover	77	70		
20	2303	Hudson	72	66		
21	2304	Grant	66	88		
22	2305	Barker	65	86		
23	2306	Miller	76	87		
24	2307	Abell	78	62		
25	2308	Cook	84	89		
26	2401	Dent	75	88		
27	2402	Franks	79	82		
28	2403	Henson	67	79		
29	2404	Jameson	69	88		
30	2405	Kraft	65	80		
31	2406	Walker	81	93		
32	2407	Tanner	72	84		
33	2408	Williams	76	90		
34						

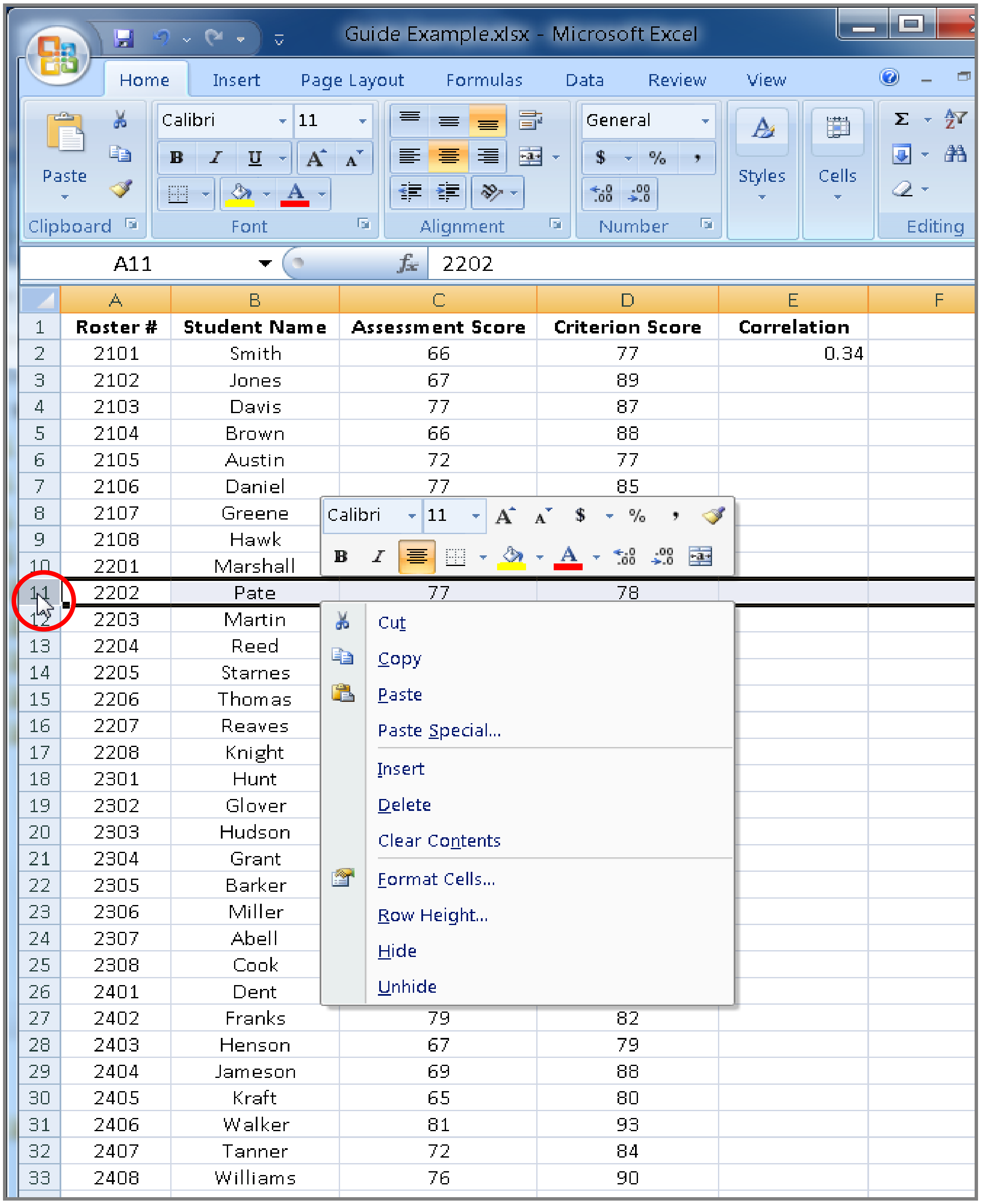
2. The same process is true for dichotomous criterion score data. Simply change any of the data you entered, hit the “Enter” key, and the correlation coefficient will be updated automatically.



	A	B	C	D	E
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation
2	2101	Smith	66	0	0.42
3	2102	Jones	67	1	
4	2103	Davis	77	1	
5	2104	Brown	66	1	
6	2105	Austin	72	0	
7	2106	Daniel	77	1	
8	2107	Greene	55	0	
9	2108	Hawk	86	1	
10	2201	Marshall	77	1	
11	2203	Martin	89	1	
12	2202	Pate	77	1	
13	2204	Reed	78	0	
14	2205	Starnes	75	0	
15	2206	Thomas	67	0	
16	2207	Reaves	66	0	
17	2208	Knight	67	1	
18	2301	Hunt	77	1	
19	2302	Glover	77	0	
20	2303	Hudson	72	0	
21	2304	Grant	66	1	
22	2305	Barker	65	0	
23	2306	Miller	76	1	
24	2307	Abell	78	1	
25	2308	Cook	84	1	
26	2401	Dent	75	1	
27	2402	Franks	79	0	
28	2403	Henson	67	0	
29	2404	Jameson	69	1	
30	2405	Kraft	65	0	
31	2406	Walker	81	1	
32	2407	Tanner	72	0	

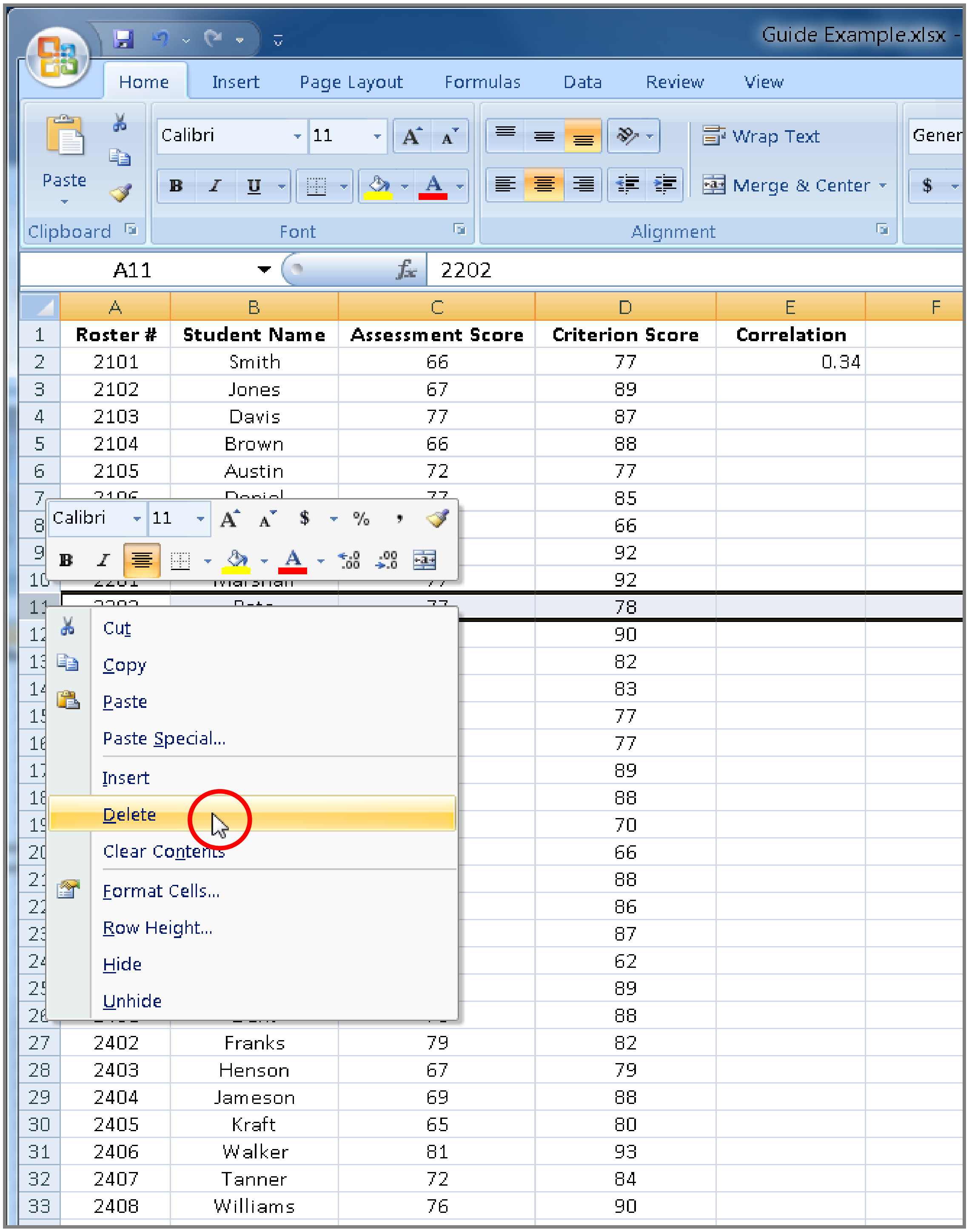
Deleting Data

1. If you need to delete an entire entry, click the right mouse button on the number of the entry to be deleted which will highlight all of the cells pertaining to that entry. This will also bring up a menu. The examples below show continuous numerical measurement data. The procedures are the same for dichotomous data.

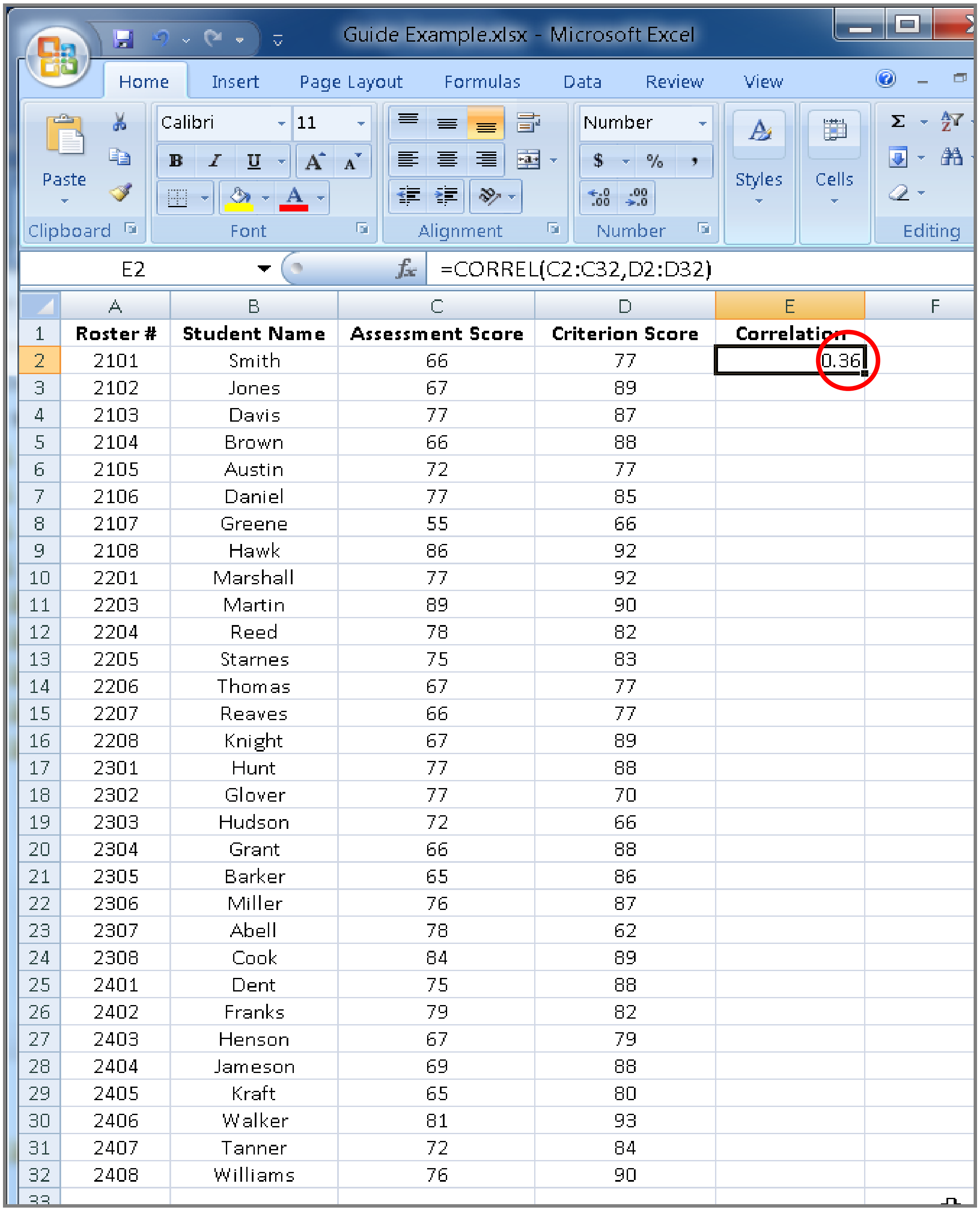


2. Inside the menu click on “Delete” and the entire row/entry will be deleted.

CAUTION: Deleting line 2, which includes the correlation formula, will also delete the formula.



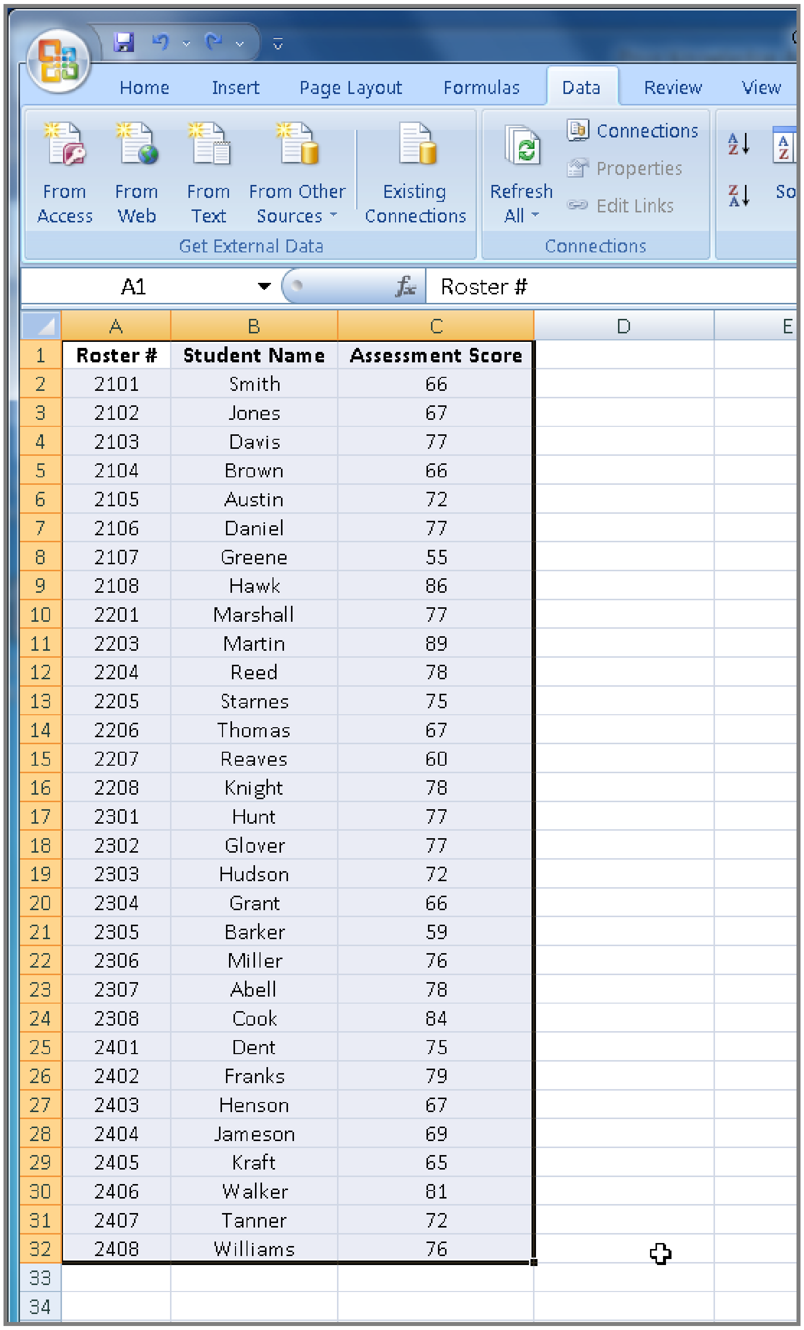
3. Notice as the entry is deleted the correlation coefficient is automatically updated.



	A	B	C	D	E	F
1	Roster #	Student Name	Assessment Score	Criterion Score	Correlation	
2	2101	Smith	66	77	0.36	
3	2102	Jones	67	89		
4	2103	Davis	77	87		
5	2104	Brown	66	88		
6	2105	Austin	72	77		
7	2106	Daniel	77	85		
8	2107	Greene	55	66		
9	2108	Hawk	86	92		
10	2201	Marshall	77	92		
11	2203	Martin	89	90		
12	2204	Reed	78	82		
13	2205	Starnes	75	83		
14	2206	Thomas	67	77		
15	2207	Reaves	66	77		
16	2208	Knight	67	89		
17	2301	Hunt	77	88		
18	2302	Glover	77	70		
19	2303	Hudson	72	66		
20	2304	Grant	66	88		
21	2305	Barker	65	86		
22	2306	Miller	76	87		
23	2307	Abell	78	62		
24	2308	Cook	84	89		
25	2401	Dent	75	88		
26	2402	Franks	79	82		
27	2403	Henson	67	79		
28	2404	Jameson	69	88		
29	2405	Kraft	65	80		
30	2406	Walker	81	93		
31	2407	Tanner	72	84		
32	2408	Williams	76	90		

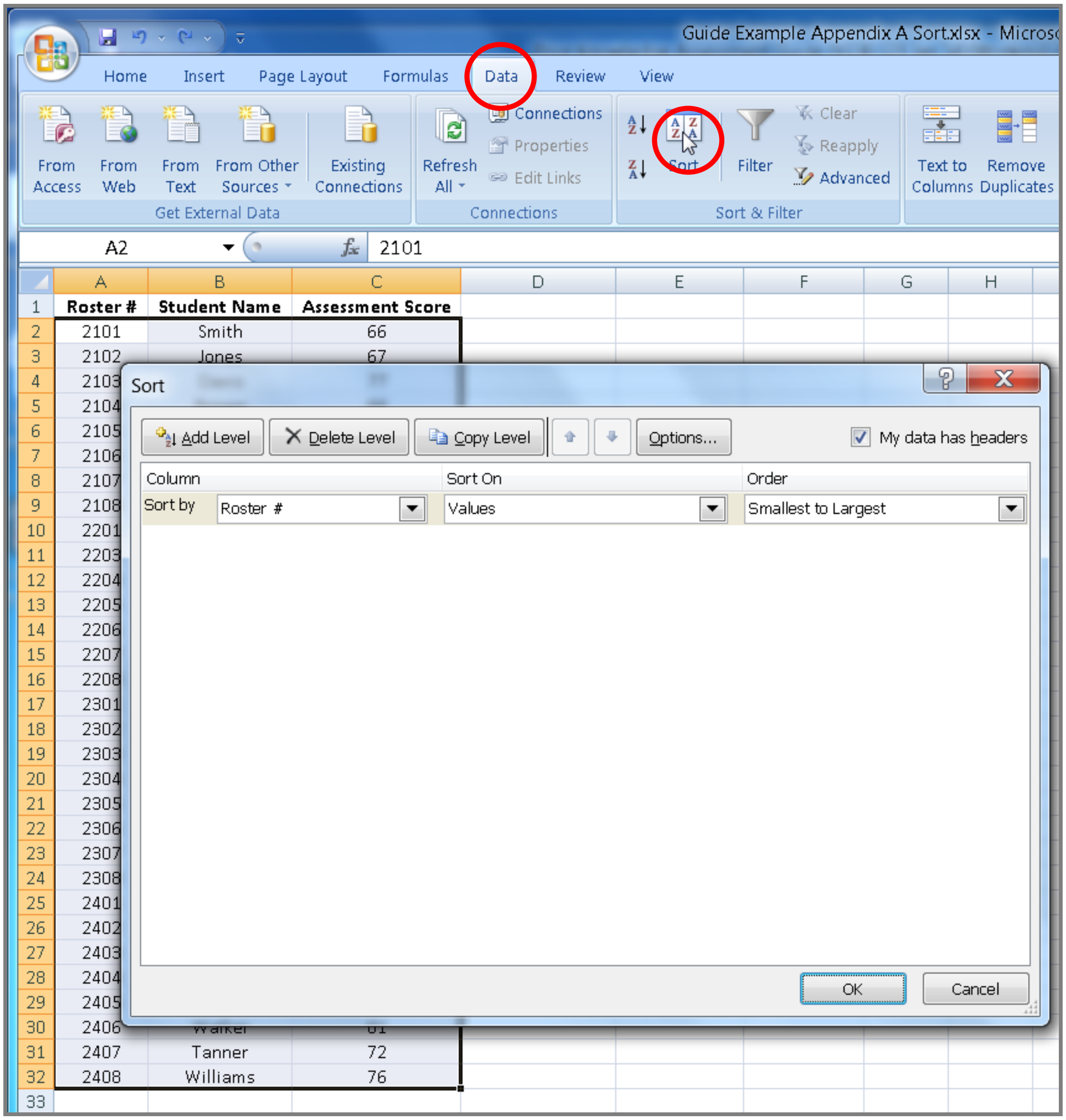
Sorting Data

1. To sort assessment scores for ease in visualization of the data, left click on the first cell containing the label for the first column (Roster #), drag to the last cell in the last column and release the button. This will highlight all of the data including the column headings. **All columns must be highlighted in order to maintain the association of student roster numbers, names, and scores. Without selecting all columns only a portion of the data will be sorted and scores will become misaligned with student names and/or roster numbers.**

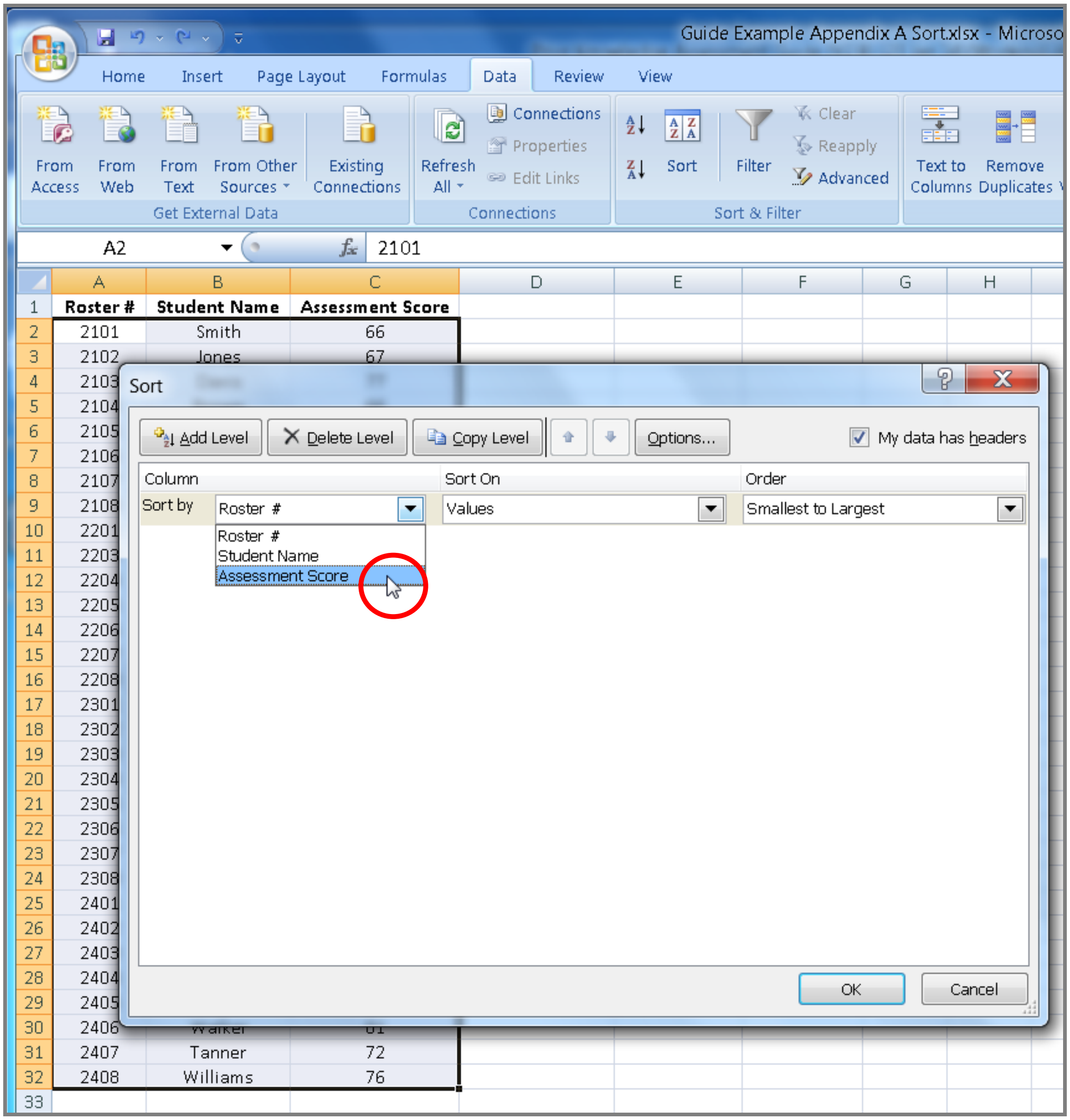


Roster #	Student Name	Assessment Score
2101	Smith	66
2102	Jones	67
2103	Davis	77
2104	Brown	66
2105	Austin	72
2106	Daniel	77
2107	Greene	55
2108	Hawk	86
2201	Marshall	77
2203	Martin	89
2204	Reed	78
2205	Starnes	75
2206	Thomas	67
2207	Reaves	60
2208	Knight	78
2301	Hunt	77
2302	Glover	77
2303	Hudson	72
2304	Grant	66
2305	Barker	59
2306	Miller	76
2307	Abell	78
2308	Cook	84
2401	Dent	75
2402	Franks	79
2403	Henson	67
2404	Jameson	69
2405	Kraft	65
2406	Walker	81
2407	Tanner	72
2408	Williams	76

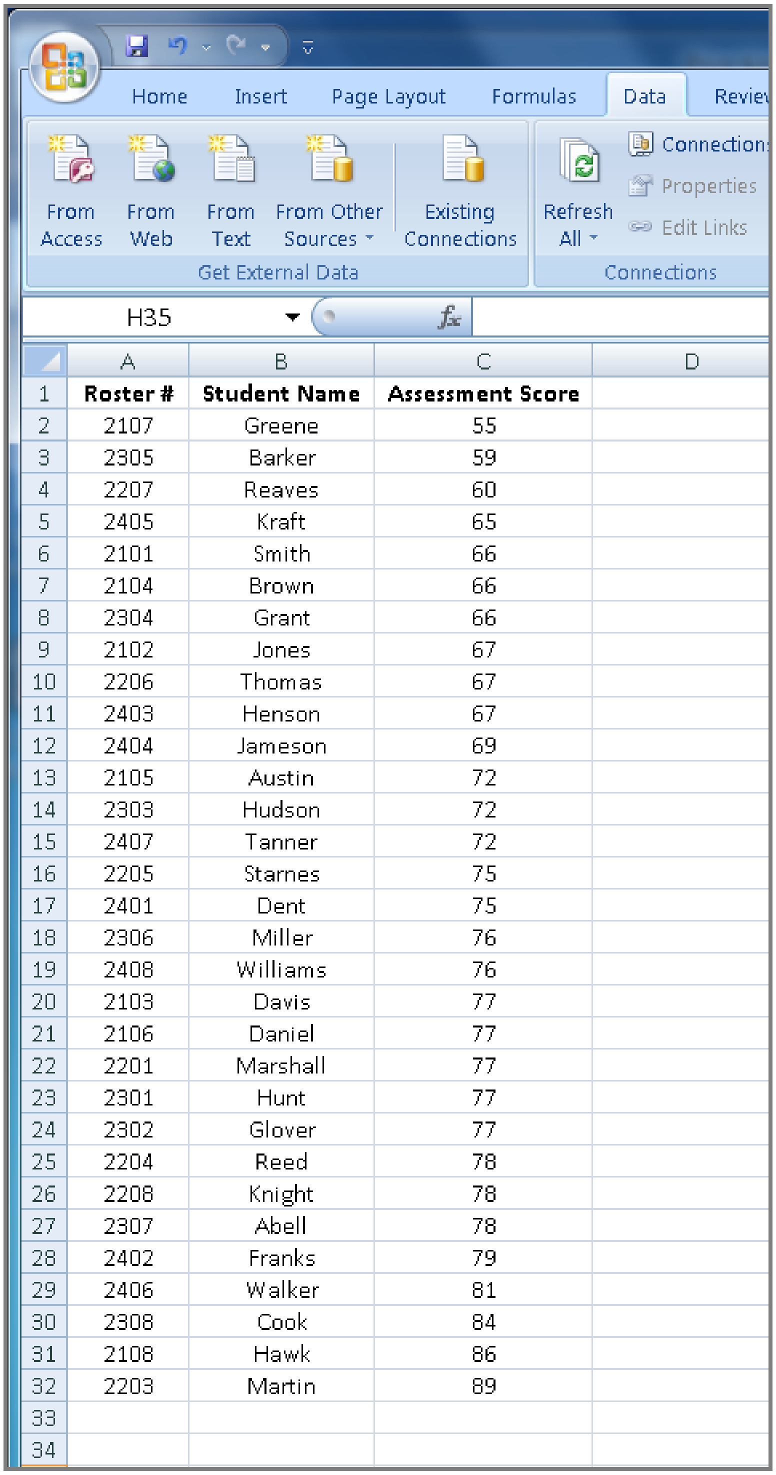
2. Left click on the "Data" tab at the top of the screen and then left click on "Sort" in the tool bar. This will bring up a "Sort" menu.



3. In the menu, click on the down arrow next to “Sort by” revealing the options. Move your pointer to “Assessment Score” and left click on that option. “Sort On” should remain on “values” and “Order” should remain on “Smallest to Largest”.



4. Click on “OK” at the bottom of the menu screen and your assessment scores will be sorted along with the associated roster number and student name.



	A	B	C	D
1	Roster #	Student Name	Assessment Score	
2	2107	Greene	55	
3	2305	Barker	59	
4	2207	Reaves	60	
5	2405	Kraft	65	
6	2101	Smith	66	
7	2104	Brown	66	
8	2304	Grant	66	
9	2102	Jones	67	
10	2206	Thomas	67	
11	2403	Henson	67	
12	2404	Jameson	69	
13	2105	Austin	72	
14	2303	Hudson	72	
15	2407	Tanner	72	
16	2205	Starnes	75	
17	2401	Dent	75	
18	2306	Miller	76	
19	2408	Williams	76	
20	2103	Davis	77	
21	2106	Daniel	77	
22	2201	Marshall	77	
23	2301	Hunt	77	
24	2302	Glover	77	
25	2204	Reed	78	
26	2208	Knight	78	
27	2307	Abell	78	
28	2402	Franks	79	
29	2406	Walker	81	
30	2308	Cook	84	
31	2108	Hawk	86	
32	2203	Martin	89	
33				
34				

Appendix C

Excel Correlation Coefficient Sample Exercises

The sample exercises located in this appendix are provided in order for you to gain experience and confidence in using Excel to determine correlation coefficients and produce scatter plots. Using the Excel software located on your computer, input the data provided in the examples to produce the requested output. If you need assistance, refer to the appropriate section in this guide for a detailed explanation.

Exercise #1 – Obtain a Correlation Coefficient

You have completed instruction on a block of training in which you plan to implement tailored training. Prior to beginning this instruction you designed a prior knowledge assessment to be used for validation and administered it to the class. You have just finished scoring the assessment and have compiled student performance scores used for your criterion. Using the information found in this guide, calculate a correlation value from your data below.

Assessment scores		**Criterion Scores**	
Roster #	Score	Roster #	Score
2114	44	2114	56
2115	42	2115	58
2117	37	2117	53
2124	35	2124	55
2125	33	2125	49
2127	39	2126	59
2128	47	2127	60
2129	41	2128	55
2132	38	2132	55
2135	29	2135	44
2137	34	2137	51
2139	35	2139	53
2144	28	2142	51
2145	46	2144	59
2146	42	2145	57
2147	45	2146	53
2148	47	2148	54
2150	43	2150	53
2151	14	2151	54
2152	33	2152	57
2154	36	2157	56
2157	40	2158	52
2158	44	2160	58
2160	45	2161	43
2161	39	2162	45
2162	33	2164	50
2164	29	2165	45
2165	27	2167	48
2167	35	2169	39
2169	46	2170	47
2170	42	2171	47
2171	41	2172	52
2172	40	2173	40
2173	29	2174	45
2174	30		

Once you have obtained a correlation coefficient turn to the next page.

Exercise #1 (continued)

You should have obtained a value of .21. If you did not, check your input and try again. You should only use data for students in which you have both scores. Missing scores may be due to recycling or various other reasons but partial scores may not be included. Scores circled in red may not be used in the calculation.

Assessment scores

Roster #	Score
2114	44
2115	42
2117	37
2124	35
2125	33
2127	39
2128	47
2129	41
2132	38
2135	29
2137	34
2139	35
2144	28
2145	46
2146	42
2147	45
2148	47
2150	43
2151	14
2152	33
2154	36
2157	40
2158	44
2160	45
2161	39
2162	33
2164	29
2165	27
2167	35
2169	46
2170	42
2171	41
2172	40
2173	29
2174	30

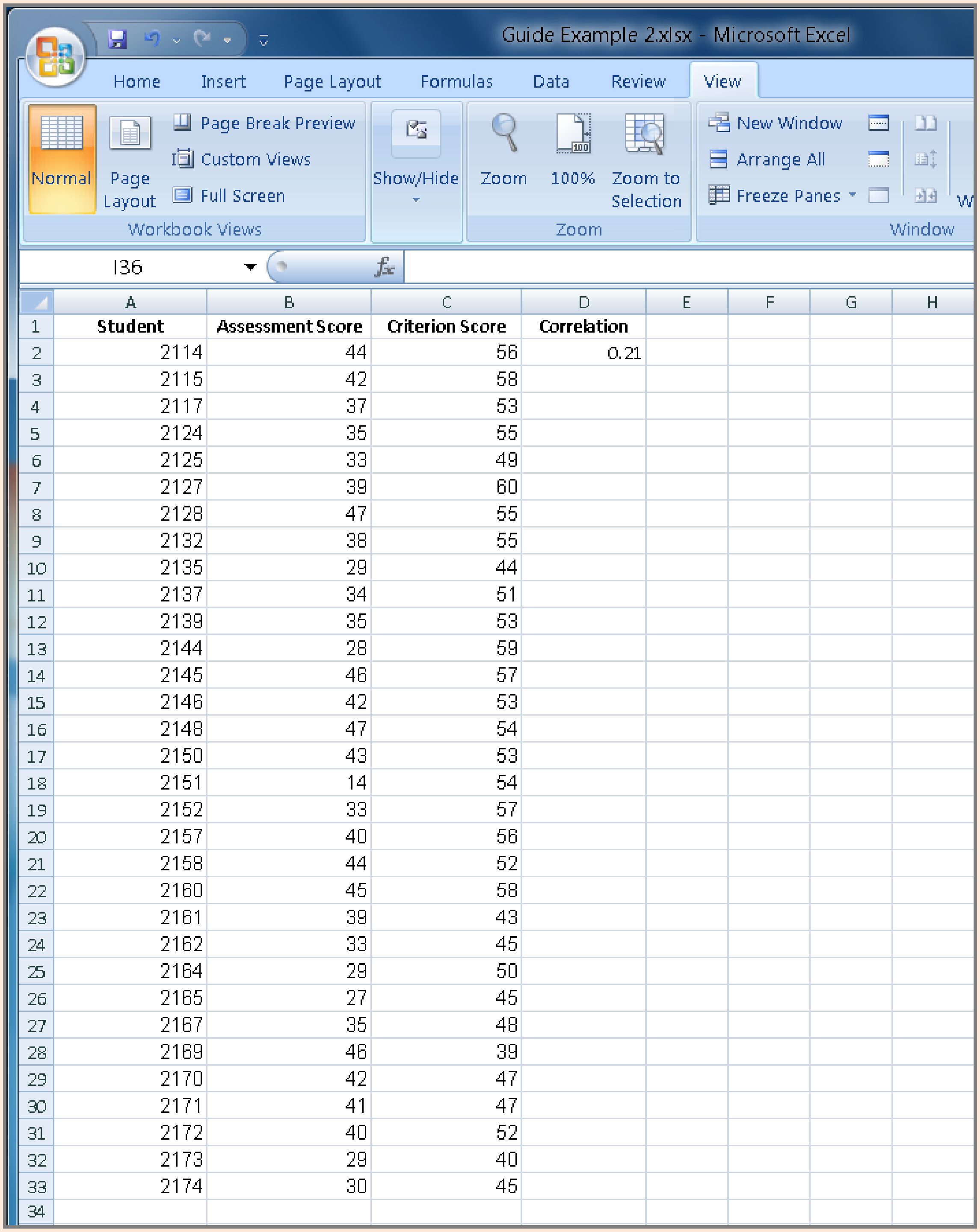
Criterion Scores

Roster #	Score
2114	56
2115	58
2117	53
2124	55
2125	49
2126	59
2127	60
2128	55
2132	55
2135	44
2137	51
2139	53
2142	51
2144	59
2145	57
2146	53
2148	54
2150	53
2151	54
2152	57
2157	56
2158	52
2160	58
2161	43
2162	45
2164	50
2165	45
2167	48
2169	39
2170	47
2171	47
2172	52
2173	40
2174	45

Once you have successfully calculated a value of .21 then continue on to the next page.

Exercise #2 – Create a Scatter Plot

Your Excel spreadsheet should look similar to the one below.
You now decide to use a scatter plot to help identify any outliers. Create a scatter plot using your input data.



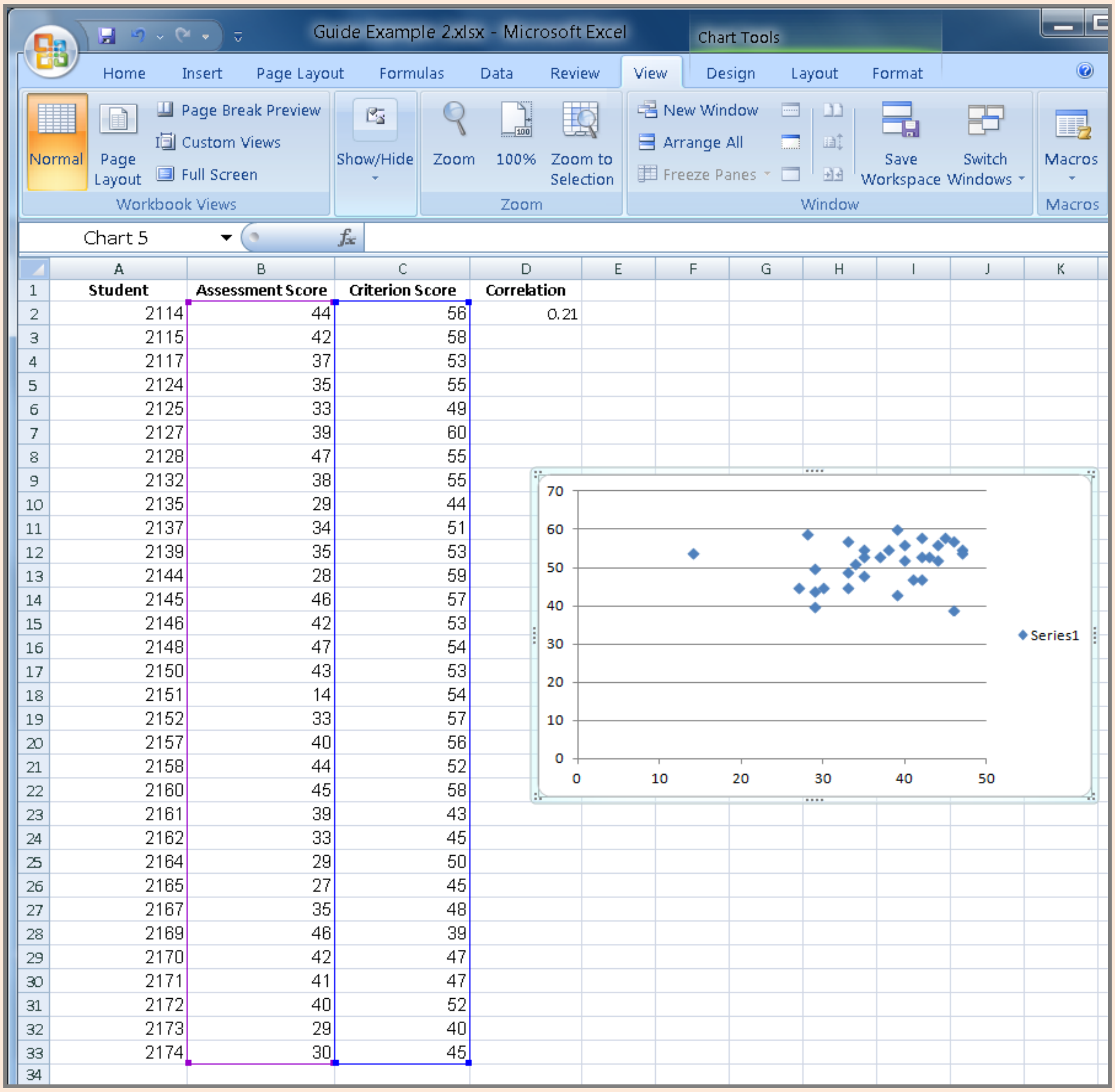
	A	B	C	D
1	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.21
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	14	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34				

Once you have successfully created a scatter plot continue on to the next page.

Exercise #3 – Correct Input Data

Your Excel spreadsheet should look similar to the one below. If not review the instructions on creating scatter plots and try again.

Looking at the scatter plot you observe that the data point for student 2151 appears to fall outside the cluster of others. Double checking the data you find that you made a data entry error and his assessment score should have been 41 rather than 14. Correct the score and obtain a new correlation value and scatter plot.



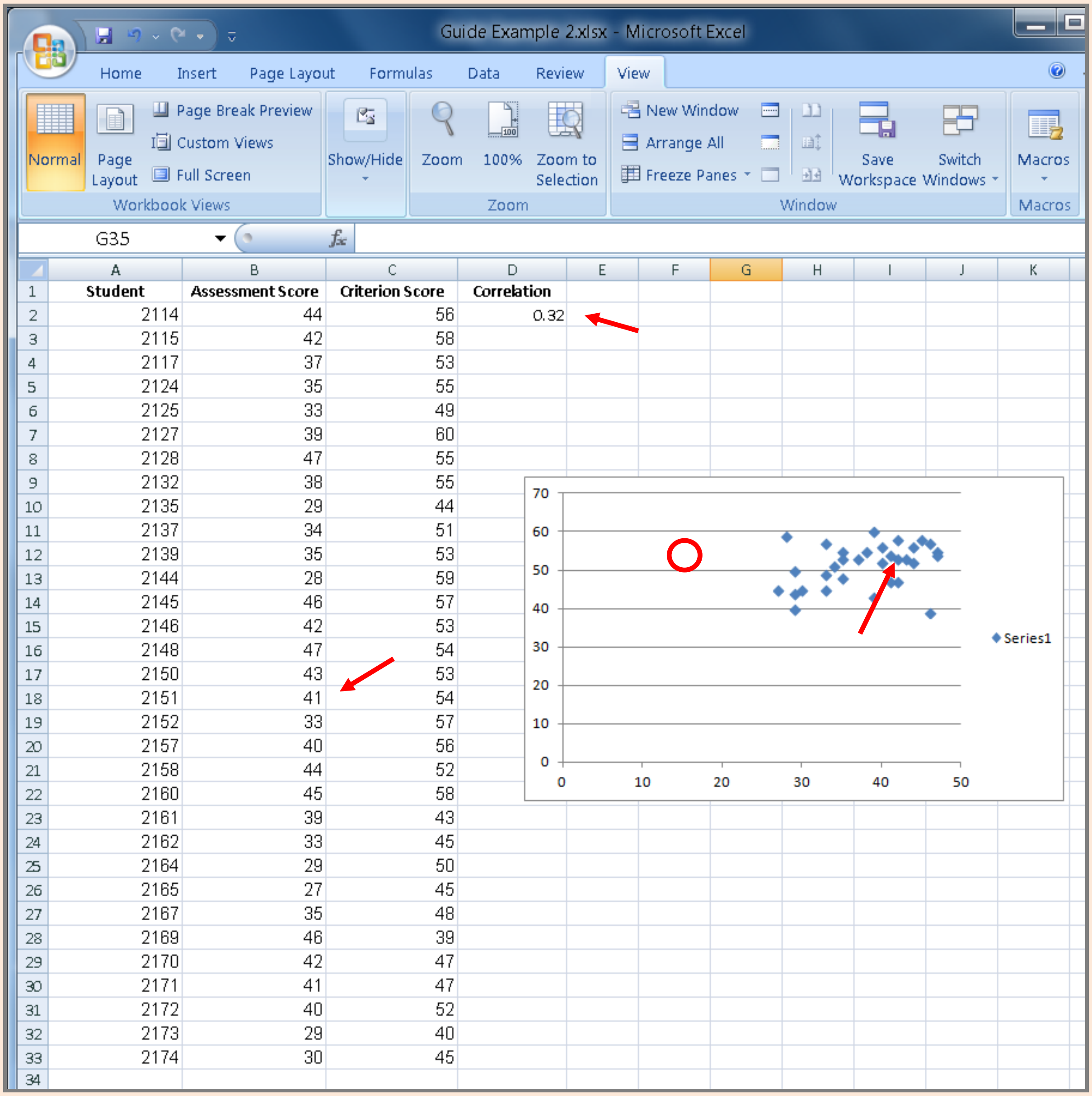
	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.21
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	14	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	

Once you have successfully changed the data and obtained a new correlation coefficient continue on to the next page.

Exercise #3 (continued)

You should have obtained a value of .32 and seen the associated data point move to a different location. If you did not, check your input and try again.

Your Excel spreadsheet should look similar to the one below.
To change the data simply click in cell B18 and replace 14 with 41 and hit "enter". This will automatically update the correlation value and scatter plot.

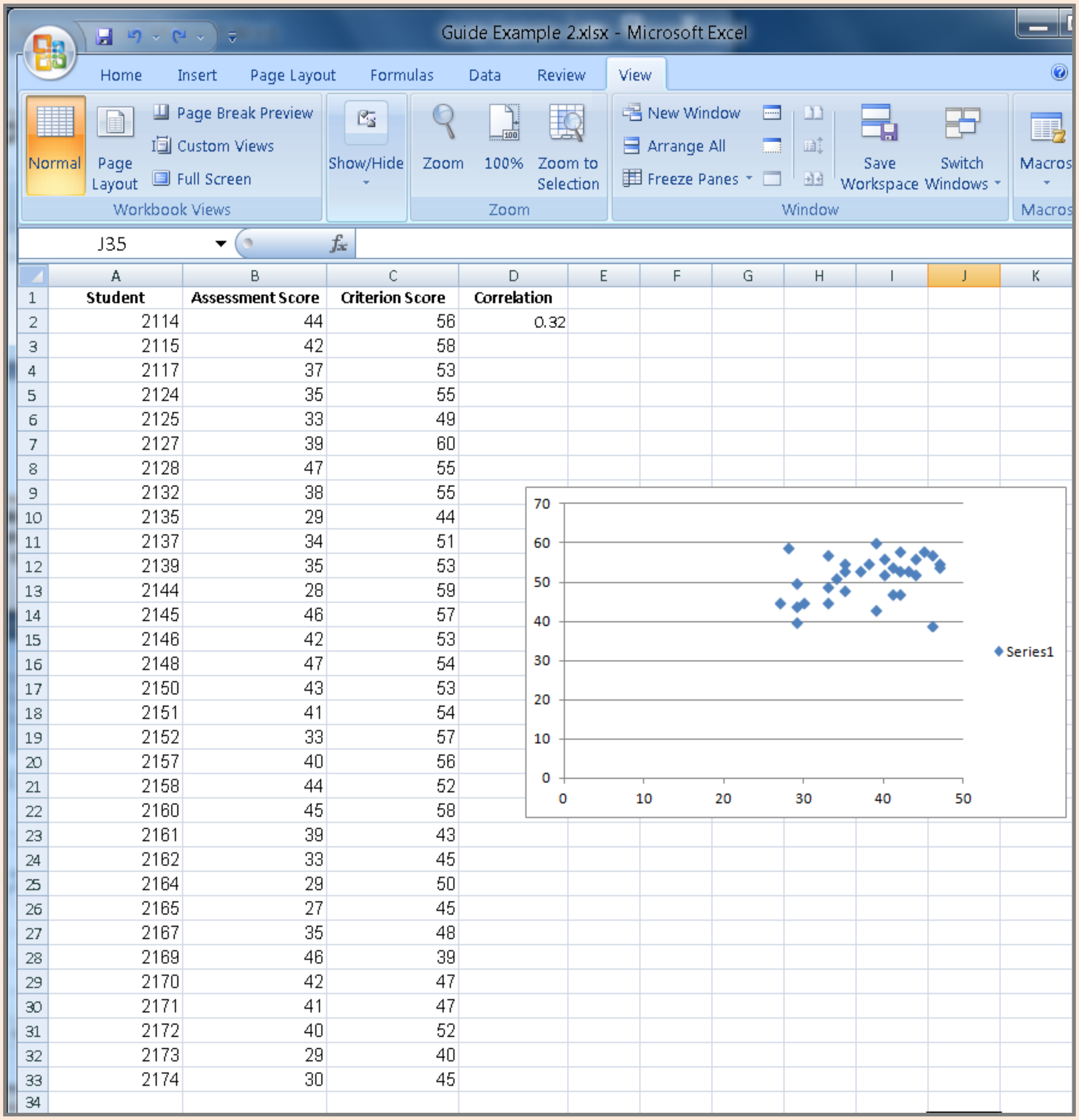


Student	Assessment Score	Criterion Score	Correlation
2114	44	56	0.32
2115	42	58	
2117	37	53	
2124	35	55	
2125	33	49	
2127	39	60	
2128	47	55	
2132	38	55	
2135	29	44	
2137	34	51	
2139	35	53	
2144	28	59	
2145	46	57	
2146	42	53	
2148	47	54	
2150	43	53	
2151	41	54	
2152	33	57	
2157	40	56	
2158	44	52	
2160	45	58	
2161	39	43	
2162	33	45	
2164	29	50	
2165	27	45	
2167	35	48	
2169	46	39	
2170	42	47	
2171	41	47	
2172	40	52	
2173	29	40	
2174	30	45	

Once you have obtained a value of .32 and successfully created the scatter plot as pictured above, continue on to the next page.

Exercise #4 – Input New Data

As you are checking the data you realize you had not recorded any data for student 2121. Student 2121 had an assessment score of 32 and a criterion score of 42. Include the new values into your input data and recalculate the correlation value and obtain a new scatter plot.



Student	Assessment Score	Criterion Score	Correlation
2114	44	56	0.32
2115	42	58	
2117	37	53	
2124	35	55	
2125	33	49	
2127	39	60	
2128	47	55	
2132	38	55	
2135	29	44	
2137	34	51	
2139	35	53	
2144	28	59	
2145	46	57	
2146	42	53	
2148	47	54	
2150	43	53	
2151	41	54	
2152	33	57	
2157	40	56	
2158	44	52	
2160	45	58	
2161	39	43	
2162	33	45	
2164	29	50	
2165	27	45	
2167	35	48	
2169	46	39	
2170	42	47	
2171	41	47	
2172	40	52	
2173	29	40	
2174	30	45	

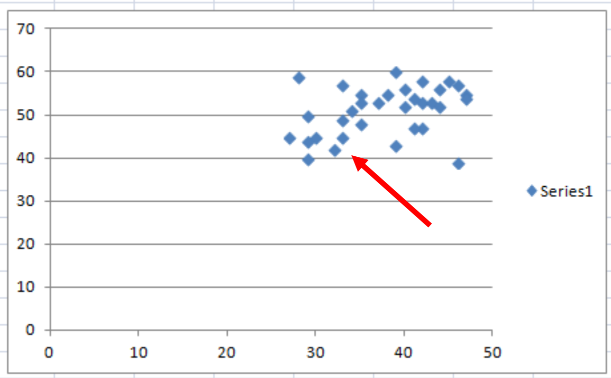
Once you have added the student data, obtained a new correlation coefficient and associated scatter plot, continue on to the next page.

Exercise #4 (continued)

You should have obtained a value of .35. If you did not, check your input and try again. Your Excel spreadsheet should look similar to the one below. Remember, you have to update the cell information for both the correlation and the scatter plot.

Guide Example 2.xlsx - Microsoft Excel

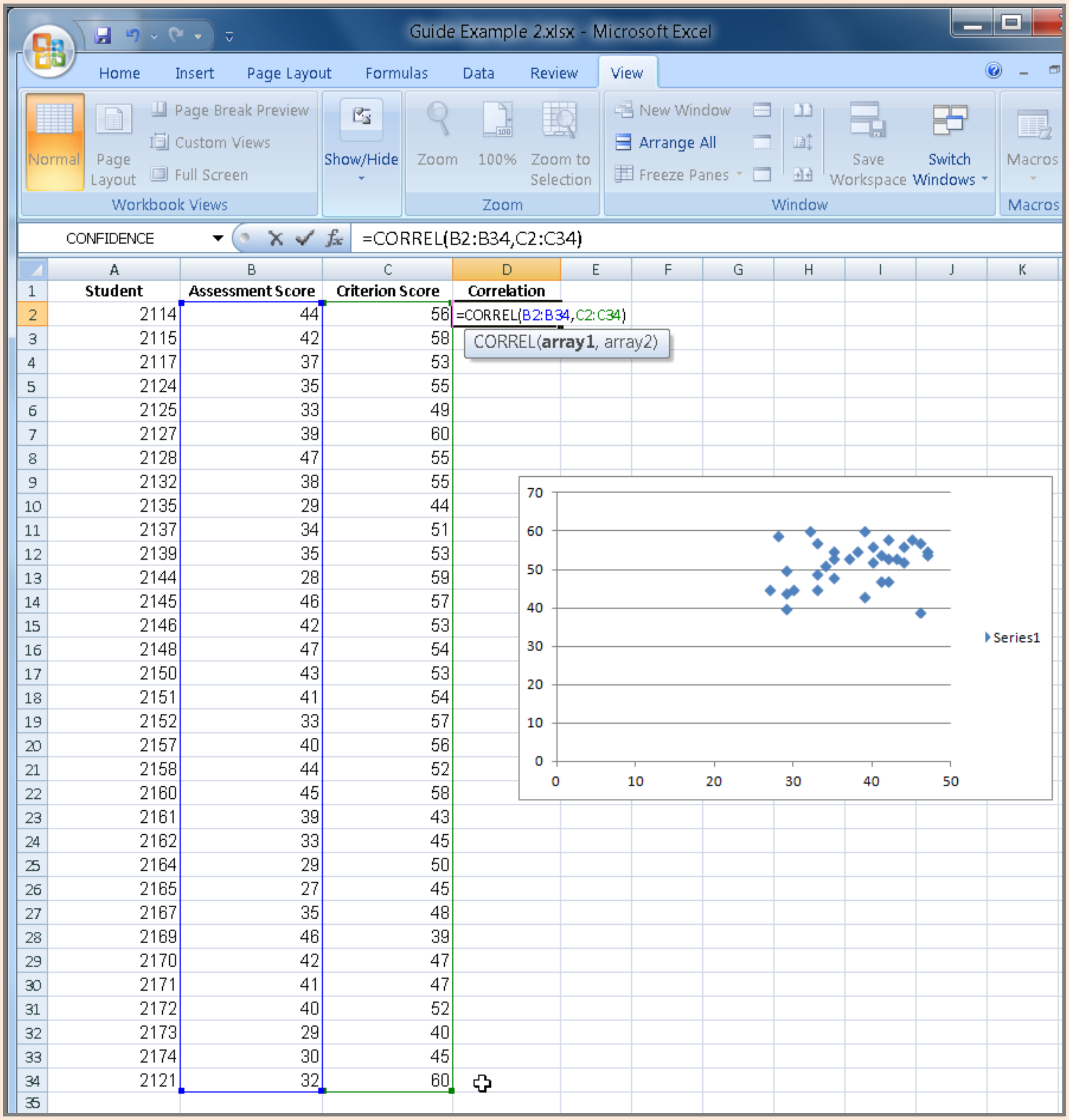
	A	B	C	D
1	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.35
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	41	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34	2121	32	42	



Continue on to the next page for further help in obtaining the correct value and adding the data point to the scatter plot.

Exercise #4 (continued)

To insert the new data, add the data to the bottom of the list. Double click on cell D2, click on "array 1" in the formula, highlight all of the assessment scores, click on "array 2", highlight all of the criterion scores and then hit the enter key on your keyboard to encompass the new data. This will automatically update the correlation value but not the scatter plot.

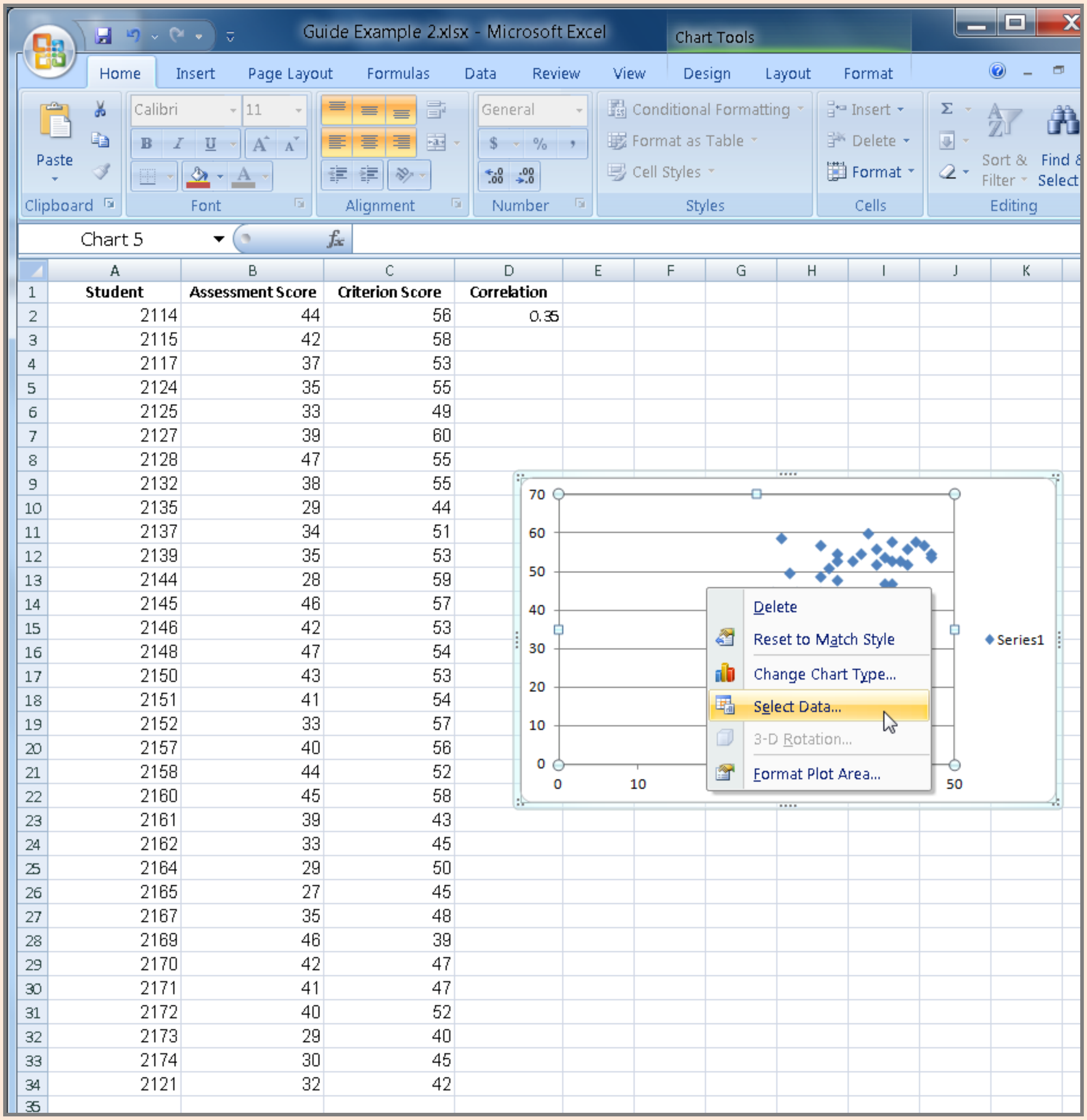


	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	=CORREL(B2:B34,C2:C34)
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	41	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34	2121	32	60	

Turn to the next page for assistance on how to update the scatter plot.

Exercise #4 (continued)

There are a number of ways to update the scatter plot. The simplest way is to click the right mouse button somewhere inside the scatter plot which will bring up a menu and then click the left mouse button on "Select data".

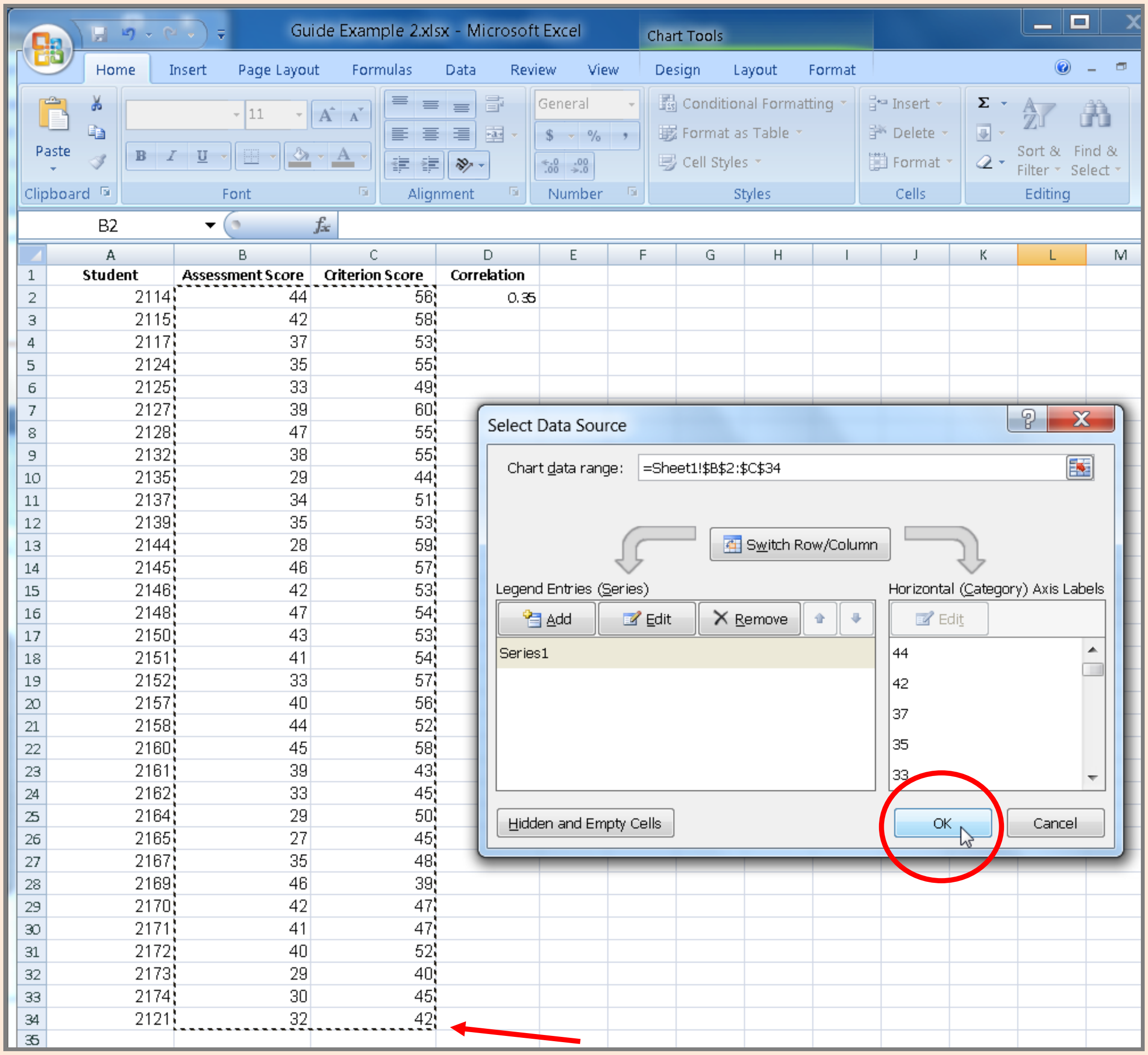


	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.35
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	41	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34	2121	32	42	

Once you have clicked on "Select data" turn to the next page.

Exercise #4 (continued)

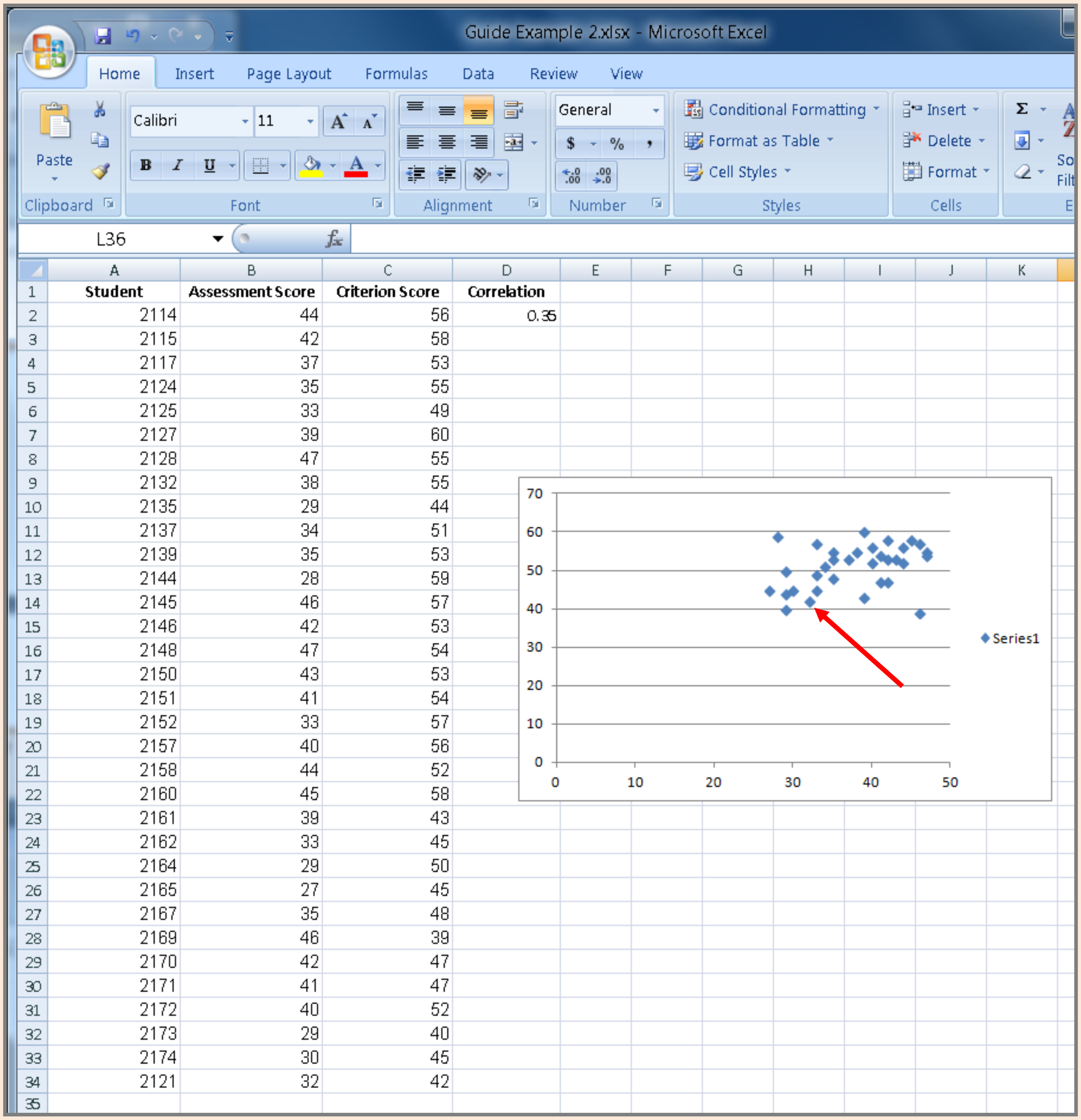
Once you have clicked on “Select data” you will see your input data for the scatter plot highlighted in a flashing dotted line along with a data source box. Your input data will not include your new entry. To update your data simply click your left mouse button on the first assessment score entry and then, without releasing the button, drag to the last criterion score entry. Now release the left mouse button. This will draw a new box around all of the data and update the data in the data source box. Once you have drawn the new box around all of the data, click “OK” at the bottom of the data source box.



Student	Assessment Score	Criterion Score	Correlation
2114	44	56	0.35
2115	42	58	
2117	37	53	
2124	35	55	
2125	33	49	
2127	39	60	
2128	47	55	
2132	38	55	
2135	29	44	
2137	34	51	
2139	35	53	
2144	28	59	
2145	46	57	
2146	42	53	
2148	47	54	
2150	43	53	
2151	41	54	
2152	33	57	
2157	40	56	
2158	44	52	
2160	45	58	
2161	39	43	
2162	33	45	
2164	29	50	
2165	27	45	
2167	35	48	
2169	46	39	
2170	42	47	
2171	41	47	
2172	40	52	
2173	29	40	
2174	30	45	
2121	32	42	

Once you have updated all data correctly turn to the next page.

Once you click “OK” at the bottom of the data source box the updated scatter plot will appear with the new data point displayed.

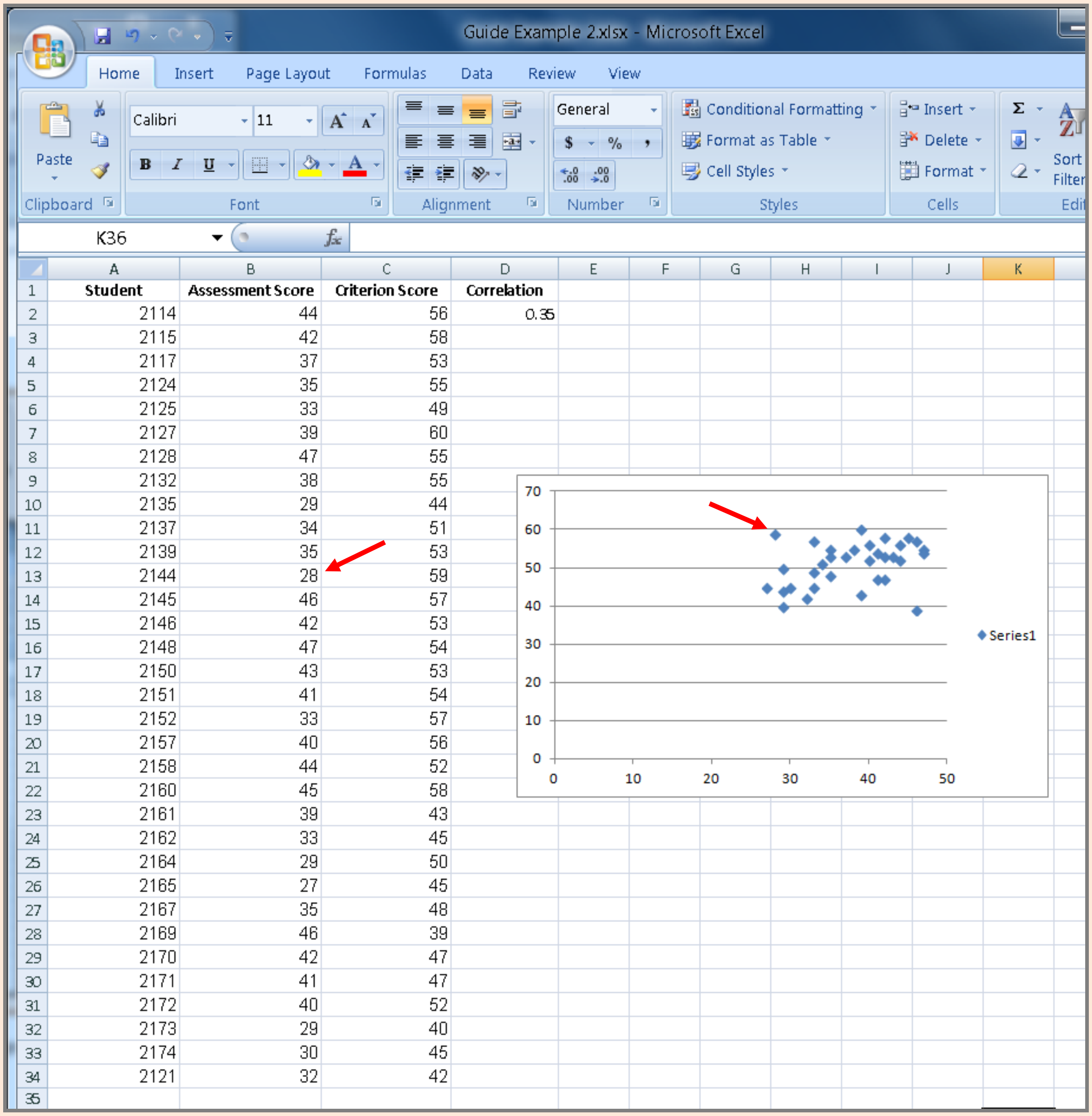


	A	B	C	D
1	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.35
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	41	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34	2121	32	42	
35				

Once you have updated your scatter plot, turn to the next page.

Exercise #5 – Delete Data

Just as you think you have finished you remember that student 2144 became sick on the day the assessment was administered and did not finish the assessment. You decide to exclude that students data from the analysis. Delete all data for student 2144 and update both the correlation value and the scatter plot.

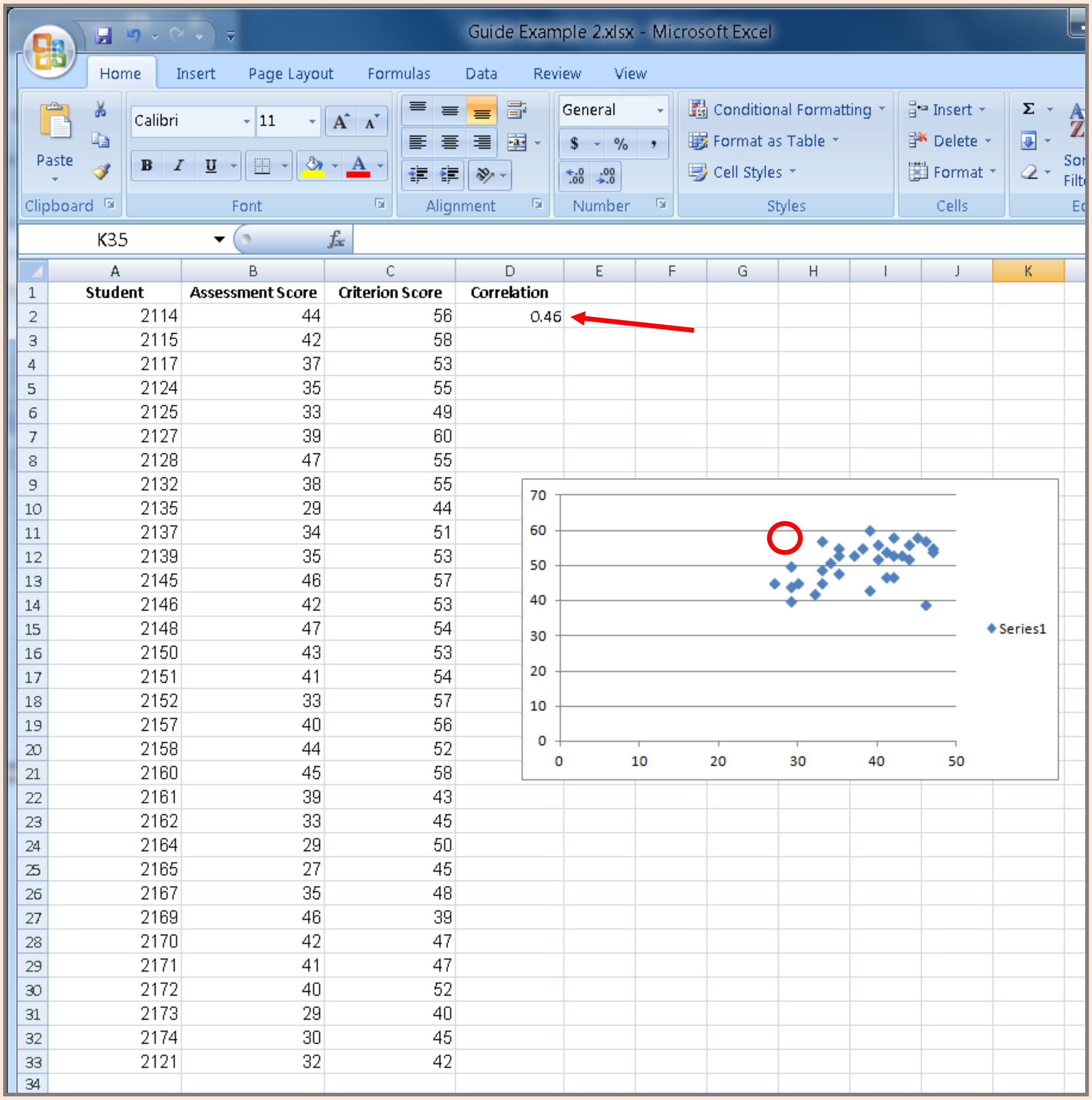


	A	B	C	D
1	Student	Assessment Score	Criterion Score	Correlation
2	2114	44	56	0.35
3	2115	42	58	
4	2117	37	53	
5	2124	35	55	
6	2125	33	49	
7	2127	39	60	
8	2128	47	55	
9	2132	38	55	
10	2135	29	44	
11	2137	34	51	
12	2139	35	53	
13	2144	28	59	
14	2145	46	57	
15	2146	42	53	
16	2148	47	54	
17	2150	43	53	
18	2151	41	54	
19	2152	33	57	
20	2157	40	56	
21	2158	44	52	
22	2160	45	58	
23	2161	39	43	
24	2162	33	45	
25	2164	29	50	
26	2165	27	45	
27	2167	35	48	
28	2169	46	39	
29	2170	42	47	
30	2171	41	47	
31	2172	40	52	
32	2173	29	40	
33	2174	30	45	
34	2121	32	42	
35				

Once you have deleted student 2144 and updated all data correctly turn to the next page.

Exercise #5 (continued)

You should have obtained a correlation value of .46 and seen the associated data point disappear. If you did not, check your input and then turn to the next page for some helpful hints.

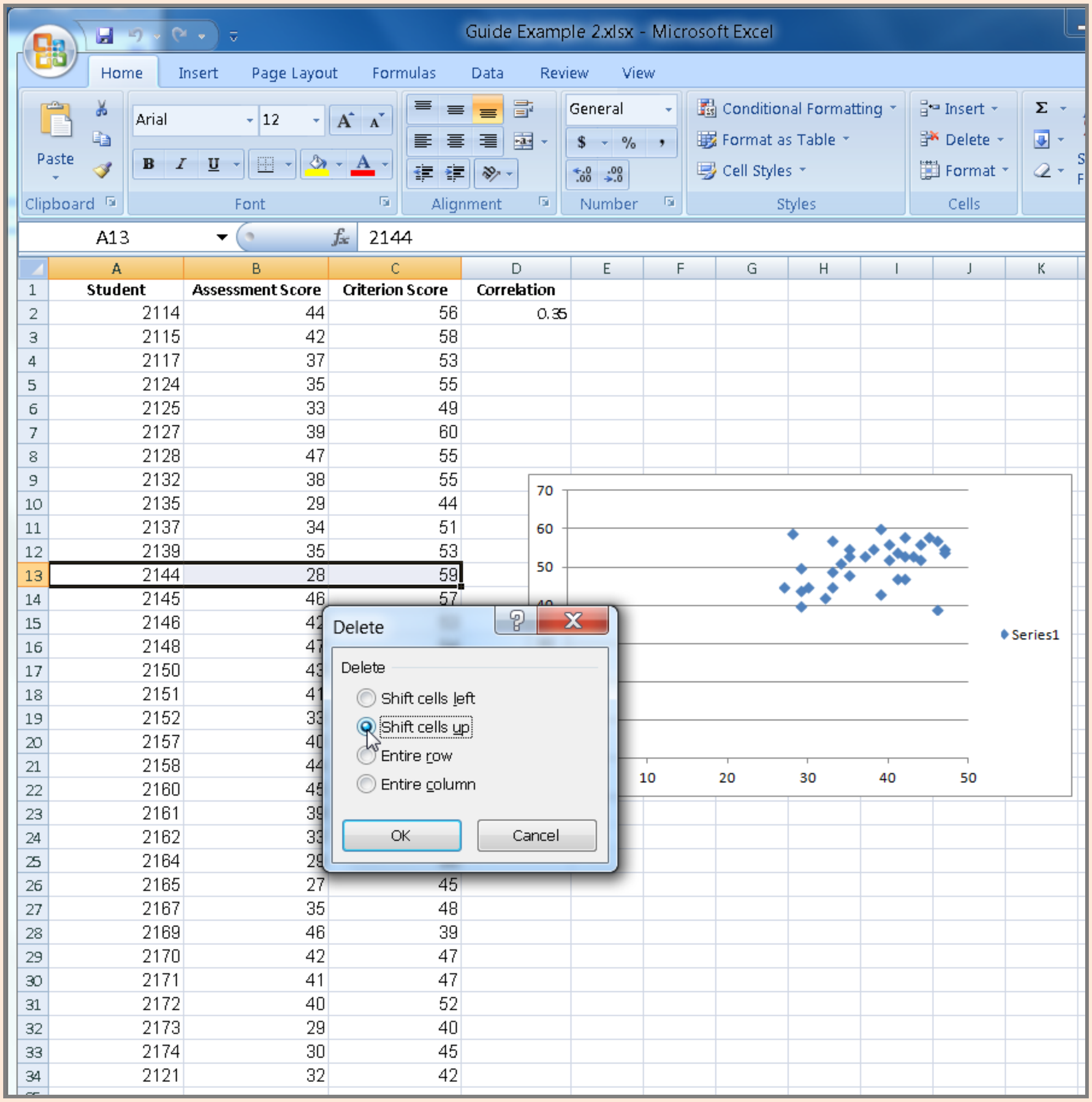


Student	Assessment Score	Criterion Score	Correlation
2114	44	56	0.46
2115	42	58	
2117	37	53	
2124	35	55	
2125	33	49	
2127	39	60	
2128	47	55	
2132	38	55	
2135	29	44	
2137	34	51	
2139	35	53	
2145	46	57	
2146	42	53	
2148	47	54	
2150	43	53	
2151	41	54	
2152	33	57	
2157	40	56	
2158	44	52	
2160	45	58	
2161	39	43	
2162	33	45	
2164	29	50	
2165	27	45	
2167	35	48	
2169	46	39	
2170	42	47	
2171	41	47	
2172	40	52	
2173	29	40	
2174	30	45	
2121	32	42	

Continue on to the next page for further help in obtaining the correct value and removing the data point from the scatter plot.

Exercise #5 (continued)

To delete the data simply highlight the entire row by clicking on the row number with the right mouse button which will also bring up a menu. Once the row is highlighted mouse over the "delete" option and click the left mouse button. When the second menu appears click the "Shift cells up" button and then click on "OK". This will delete all data associated with that row and the correlation value and scatter plot will be updated automatically.



Exercise #6 – Obtain a Correlation Coefficient with Dichotomous Data

Using the information found in this guide for obtaining a correlation coefficient from data containing a dichotomous measurement, calculate a value from the data below.

Assessment scores

Roster #	Score
2114	44
2115	42
2117	37
2124	35
2125	33
2127	39
2128	47
2129	41
2132	38
2135	29
2137	34
2139	35
2144	28
2145	46
2146	42
2147	45
2148	47
2150	43
2151	14
2152	33
2154	36
2157	40
2158	44
2160	45
2161	39
2162	33
2164	29
2165	27
2167	35
2169	46
2170	42
2171	41
2172	40
2173	29
2174	30

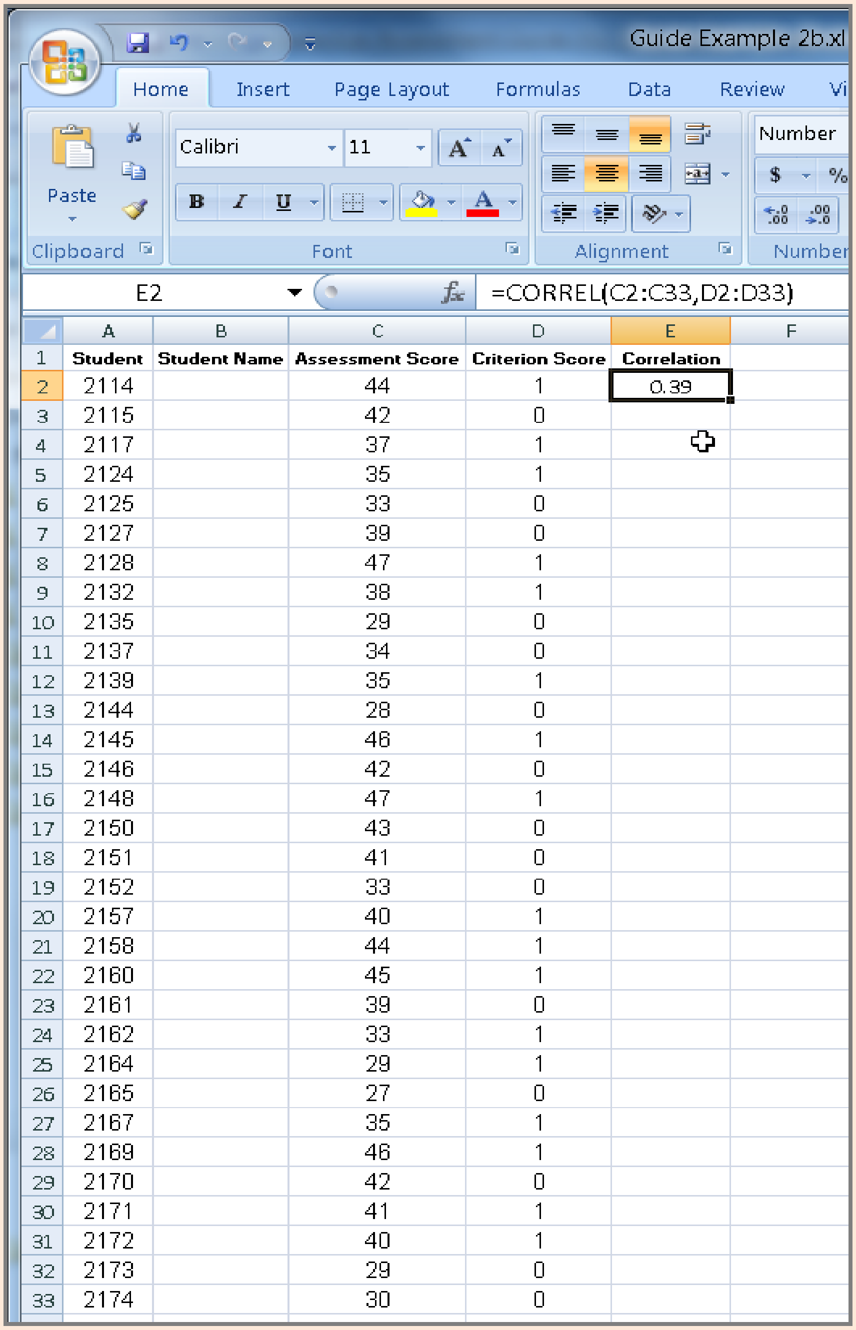
Criterion Scores

Roster #	Score
2114	1
2115	0
2117	1
2124	1
2125	0
2126	0
2127	0
2128	1
2132	1
2135	0
2137	0
2139	1
2142	0
2144	0
2145	1
2146	0
2148	1
2150	0
2151	0
2152	0
2157	1
2158	1
2160	1
2161	0
2162	1
2164	1
2165	0
2167	1
2169	1
2170	0
2171	1
2172	1
2173	0
2174	0

Once you have obtained a value, continue on to the next page.

Exercise #6 – Obtain a Correlation Coefficient with Dichotomous Data

You should have obtained a value of .39. If you did not, check your input and try again. Your Excel spreadsheet should look similar to the one below.



	A	B	C	D	E	F
1	Student	Student Name	Assessment Score	Criterion Score	Correlation	
2	2114		44	1	0.39	
3	2115		42	0		
4	2117		37	1		
5	2124		35	1		
6	2125		33	0		
7	2127		39	0		
8	2128		47	1		
9	2132		38	1		
10	2135		29	0		
11	2137		34	0		
12	2139		35	1		
13	2144		28	0		
14	2145		46	1		
15	2146		42	0		
16	2148		47	1		
17	2150		43	0		
18	2151		41	0		
19	2152		33	0		
20	2157		40	1		
21	2158		44	1		
22	2160		45	1		
23	2161		39	0		
24	2162		33	1		
25	2164		29	1		
26	2165		27	0		
27	2167		35	1		
28	2169		46	1		
29	2170		42	0		
30	2171		41	1		
31	2172		40	1		
32	2173		29	0		
33	2174		30	0		

Once you have reviewed your data with the spreadsheet above, continue on to the next page for some helpful hints on common errors.

Exercise Helps – Helpful Tips for Common Errors

If you are having trouble with obtaining the correct answers for any of the exercises, review the list of tips below for further assistance.

1. **Make sure you have only entered data for students with both an assessment and a criterion score.**
2. **Ensure that the proper scores are recorded for the proper student name/roster number.**
3. **Ensure that all calculations begin with an equal (=) sign.**
4. **Ensure that functions that include an array, such as "=SUM(D2:D33)", include all of the values it should have without including the heading name for the array. You can check the cell identifiers, such as "D2" and "D33", within the function to ensure all are correctly entered.**
5. **Ensure all formulas include the correct cell identifiers as well as the correct mathematical symbols.**
6. **Ensure all parentheses are placed in the correct position inside formulas.**
7. **Ensure that if you have added data that you update the corresponding formulas to include the new data.**
8. **If using scatter plots, remember that scatter plot data must be updated separately when changing original input data.**
9. **If any sorting of input data has been accomplished, ensure all data pertaining to a particular individual moves with that entry.**

Appendix D

Example Questions Used in Actual Prior Knowledge Assessments

The following questions were used in a variety of different prior knowledge assessments and are provided as further examples of the points reviewed in this guide.

From marksmanship training:

Directions: Circle the answer you select.

1. A bullet flying through the air is acted upon primarily by two forces which change the direction and velocity of its motion. These two forces are?

    a. Temperature and Humidity
    b. Elevation and Friction
    c. Bullet Weight and Caliber
    d. Gravity and Air Resistance
    e. I don't know

2. The path of flight that the bullet will take when it is fired from the rifle is known as what?

    a. Max ordinance
    b. Trajectory
    c. Terminal ballistics
    d. Physics
    e. I don't know

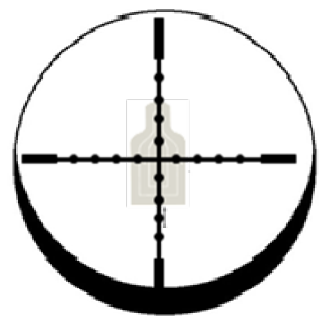
3. What happens when a bullet leaves the bore of the rifle in which the barrel is horizontal to the ground and the line of sight is parallel to the line of bore

    a. It will fly straight until it hits the target
    b. It will go up due to its aerodynamic properties
    c. It will immediately begin to fall to the earth
    d. It depends on the Ballistic Coefficient
    e. I don't know

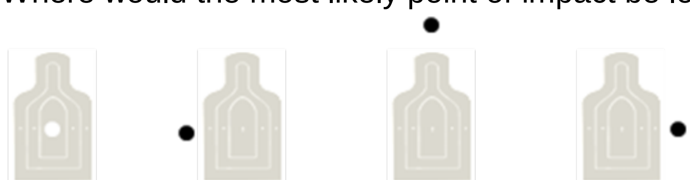
4. How many times will the bullet cross your line of sight before it hits the target when engaging a 350 yard target with a 300 yard Battle Sight Zero while aiming center mass?

    a. Once
    b. Twice
    c. Three times
    d. It won’t cross at any time
    e. I don’t know

5. If your field of view through the DOS resembled this:

    Where would the most likely point of impact be located?

    A B C D

    a. A
    b. B
    c. C
    d. D
    e. None of the above
    f. I don’t know

From land navigation training:

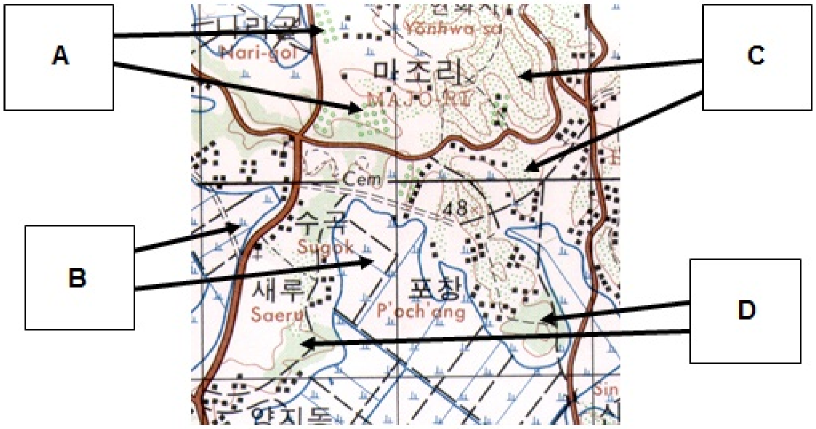
1. Select the type of major terrain feature identified by the boxes.

HILLS
RIDGES
SADDLES
VALLEYS
DEPRESSIONS

2. An eight digit coordinate locates a point on the ground to within _______?

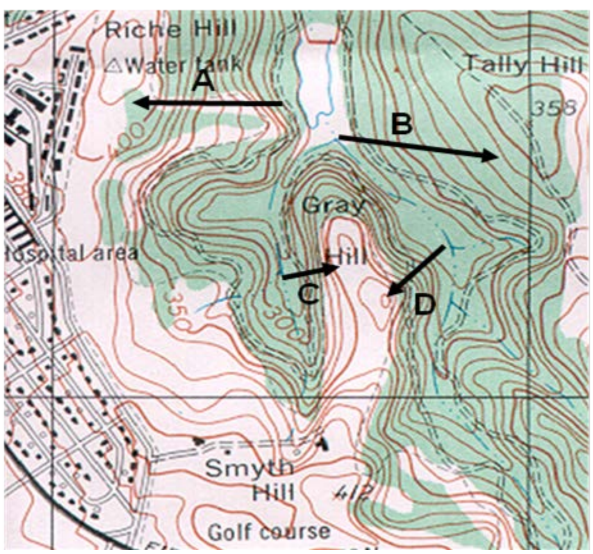
   a. 100 meters
   b. 1 meter
   c. 100 feet
   d. 10 meters

3. Military topographic maps use colors and symbols to depict various types of ground cover, forest types, and cultivation. Match the symbol with the type of plant life or vegetation that it depicts. Enter the letter for the symbol in the appropriate blank. (NOTE: Not all letters may match descriptions; if no match is found place an "**X**" in the answer space.)

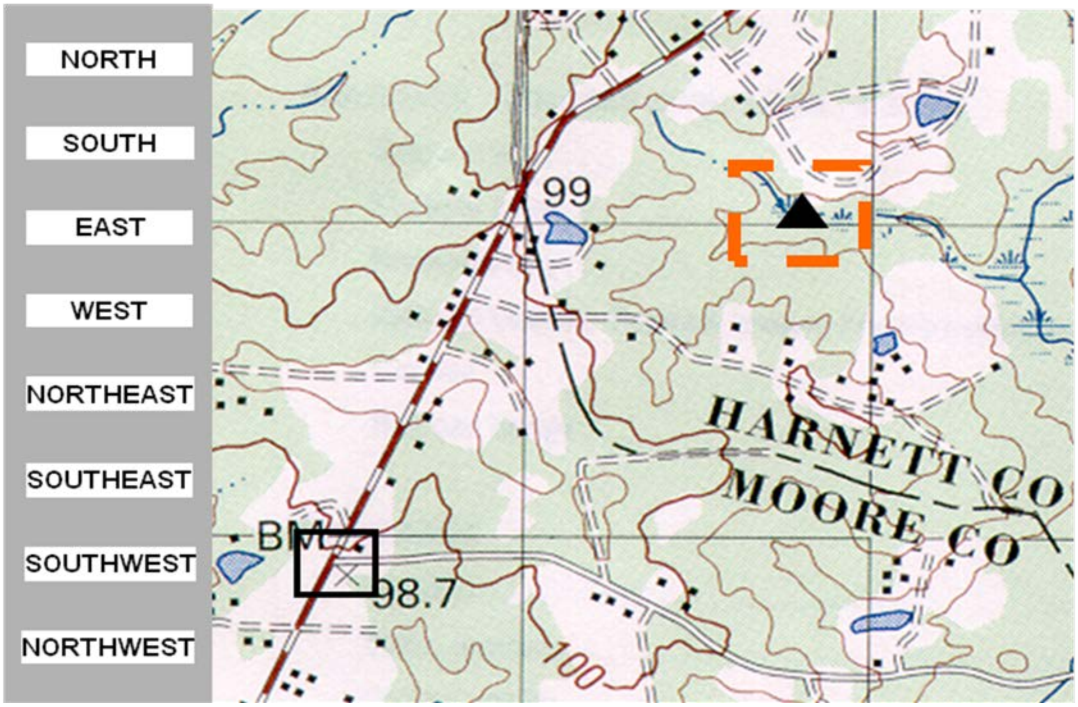


___ Brush and scrub ___ Orchards ___ Rice paddies ___ Open fields

4. The contour interval of 10 feet is identified in the legend of for this map. Which labeled arrow contains the steepest climb? (Circle the best answer.)



5. From your location at the center of the triangle in the dashed orange box, what is the direction of movement to the road junction in the black box? (Circle the correct answer.)

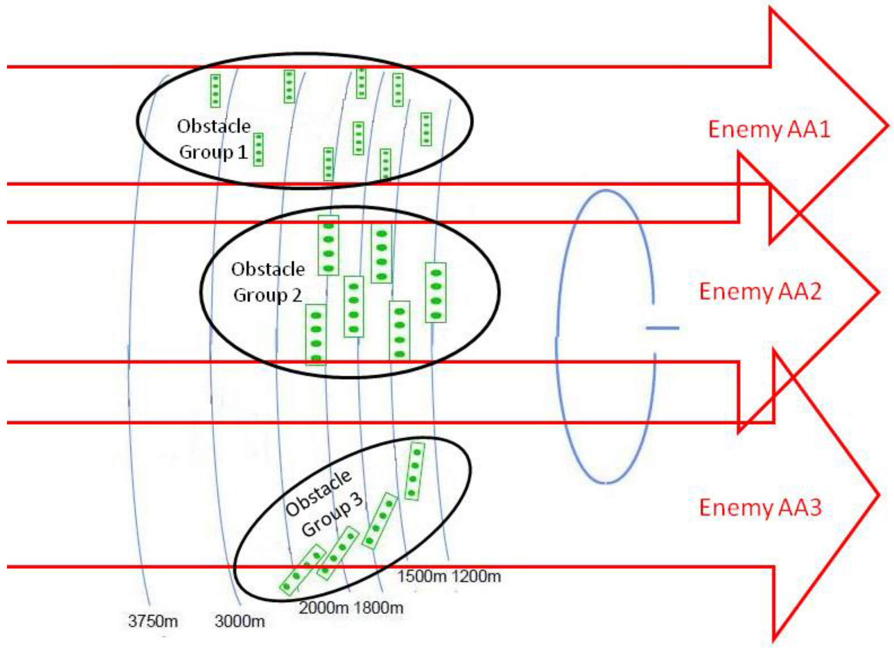


6. You remain at the same location as in the previous question. What is the approximate grid azimuth to the road junction in the black box (Circle the correct answer)

315^{o} 225^{o} 25^{o} 157^{o} 190^{o} 362^{o} 265^{o}

From engineer operations and planning training:

The example below depicts varied obstacle groups along enemy avenues of approach through a company position. Normally, a company-team will have the mission to cover only one or two obstacle groups in the defense. Answer questions 18 – 19 referring to the sketch below:



1. Match the Obstacle Groups with the desired effect that the commander desires along each enemy avenue of approach. (Enter the letter for the obstacle effect beside the Obstacle Group. Obstacle effects may be used more than once or not at all.)

____ Obstacle Group 1

____ Obstacle Group 2

____ Obstacle Group 3

A. Disrupt Effect

B. Obstruct Effect

C. Turn Effect

D. Block Effect

E. Fix Effect

2. Along which Enemy AA would you expect to find the greatest concentration of planned massed direct and indirect fires integrated with the obstacles? (Select one answer.)

____ A. Avenue of Approach 1

____ B. Avenue of Approach 2

____ C. Avenue of Approach 3

____ D. Planned direct and indirect fires would be equally distributed across all AAs.

3. Identify factors that you, as the TF Engineer, should consider when developing the work plan and obstacle execution matrix for the available engineers and excavation resources? (Circle all that apply; one or more responses are correct.)

   A. Time available to prepare the defense

   B. Construction materials or munitions required and available

   C. Priorities established by the maneuver commander

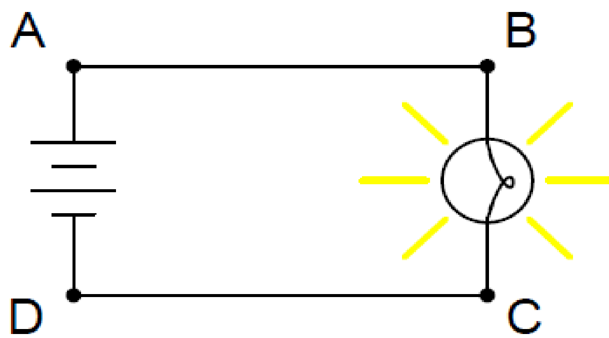
   D. Fuel consumption rates for all excavation systems, troop carriers, and prime movers

   E. Excavation or emplacement systems available and their projected operational readiness rate(s)

   F. Travel time between primary work sites

From electrical maintenance training:

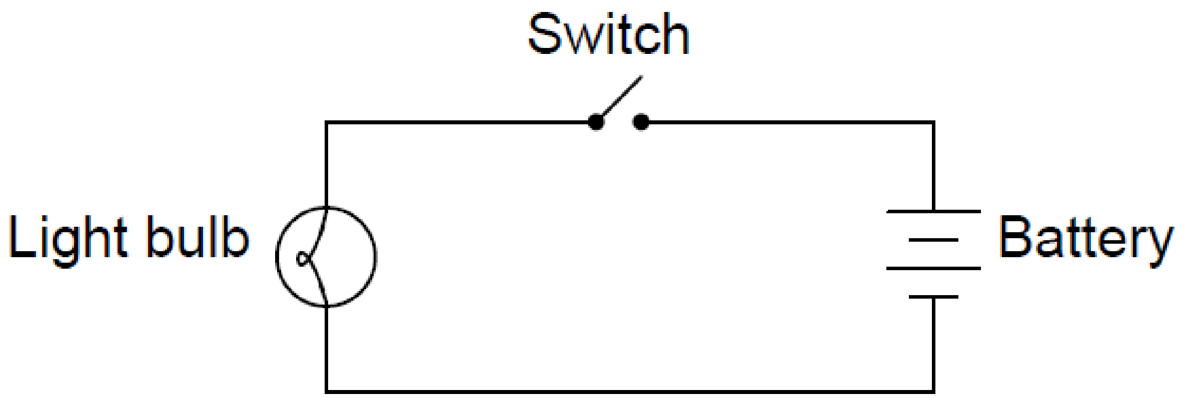
1.



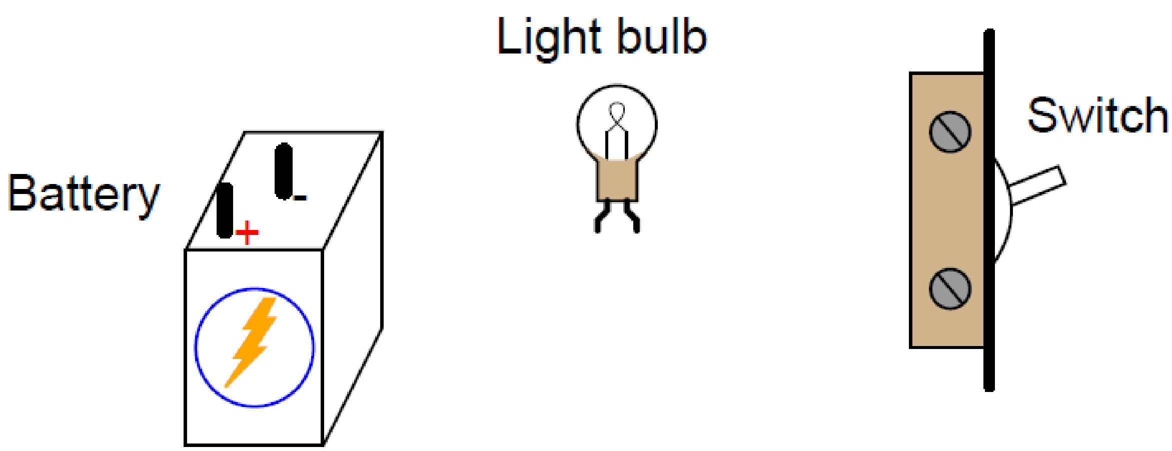
This circuit has four ”test points” labeled with the letters A, B, C, and D. Assuming the circuit is functioning (light bulb is energized), determine whether or not there will be substantial voltage between the following sets of points:

- Between A and B: ____ Voltage _____ No Voltage _____ Don’t Know
- Between B and C: ____ Voltage _____ No Voltage _____ Don’t Know
- Between C and D: ____ Voltage _____ No Voltage _____ Don’t Know
- Between D and A: ____ Voltage _____ No Voltage _____ Don’t Know
- Between A and C: ____ Voltage _____ No Voltage _____ Don’t Know
- Between D and B: ____ Voltage _____ No Voltage _____ Don’t Know

2. Examine this schematic diagram:



Now, without moving the following components, show how they may be connected together **with wires** to form the same circuit depicted in the schematic diagram above. **Please draw lines indicating the wires.**



_____ Don't Know

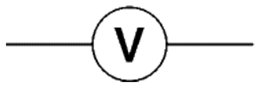
3. Identify the “circuit symbol” with its corresponding component.

A. 

Earth (Ground) ____________ _____ Don’t Know

B. 

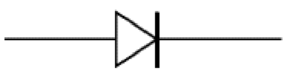
Motor ____________ _____ Don’t Know

C. 

Transistor PNP ____________ _____ Don’t Know

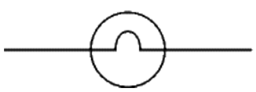
D. 

Diode ____________ _____ Don’t Know

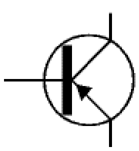
E. 
Lamp (Indicator) ____________ _____ Don’t Know

F. 
Ammeter ____________ _____ Don’t Know

Voltmeter ____________ _____ Don’t Know

G. 

Ohmmeter ____________ _____ Don’t Know

H. 

Coil; Solenoid ____________ _____ Don’t Know

I.